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Report from the Conference of the Swedish National Committee for Physics in 1959

By Erik Rudberg and Lamek Hulthén

The Swedish National Committee for Physics held its 10th General Physics Conference on June 1–3, 1959 in Stockholm. The Royal Institute of Technology had generously invited the Swedish physicists and their guests to use its lecture halls and other excellent facilities for the meeting. The large number of contributed papers made it necessary to run as many as three discussion sections in parallel for part of the time. Altogether twenty-two sessions were held. Thus the three days of the conference became, in fact, quite heavily engaged in a programme devoted to the presentation of papers and to the ensuing discussions.

In addition the participants had received an invitation to visit the new research establishment of AB Atomenergi at Studsvik, one hundred kilometers to the south of Stockholm. The demonstration of the laboratories, still largely under construction, which was arranged for the visitors at Studsvik, conveyed a strong impression of the valuable research facilities that will soon be available at the establishment.

The National Committee for Physics had the pleasure to welcome to this conference some distinguished scientists from other countries. Special guest lectures were given by H. Maier-Leibnitz from "Laboratorium für Technische Physik der Technischen Hochschule" in Munich, who spoke on "Das Forschungsprogramm des Münchenen Reaktors", and by C. J. Gorter of "Kamerlingh Onnes Laboratorium", Leiden, who discussed "Orienting atomic nuclei at low temperatures". Introductory invited papers were also delivered by Oskar Klein, whose lecture bore the title "On the systematics of elementary particles", and by Hannes Alfvén, who dealt with the subject of "Plasma physics and magneto-hydrodynamics". Short summaries of the other papers presented at the conference are given in the remainder of this report.

Dr. Björn Åström of the Nobel Institute of Physics very ably served as the Secretary of the Conference.

B. Agdur, *Department of Electronics, Royal Institute of Technology, Stockholm*

Propagation of electromagnetic waves in a plasma

The theory of wave propagation in bounded and unbounded plasma is studied for arbitrary values of the plasma density and the static magnetic field in which the plasma is assumed to be immersed. The effect of radial variation in the plasma density on the wave propagation is investigated. The phase and group velocities of the different waves are discussed and special attention is given to the properties of waves with low phase velocities. Amplification of waves in the plasma is studied. Experimental investigations of wave propagation in a splasma and possible applications are described.

O. ALMÉN and G. BRUCE, *Department of Physics, Chalmers University of Technology, Gothenburg*

On the collection of 10–50 keV ions in metals

When ions of sufficient energy impinge on a metal surface some ions penetrate through a small distance and are collected in the metal lattice. However, the quantity possible to collect is limited, and the saturation value depends on different factors, e.g. the penetration depth and the surface sputtering. In connection with electromagnetic isotope separator work, saturation values and sputtering have been measured, using krypton and rubidium ions. In addition, the variation of the sputtering coefficient with ion energy has been determined for rare gas ions impinging on the following metals: copper, silver, gold, palladium, platinum, tungsten and tin.

T. ALVÄGER, J. UHLER and O. MELIN, *Nobel Institute of Physics, Stockholm*

Mass number determination of some radioactive Sn, Sb and Te isotopes in the mass region 125–135

The isotopes in the vicinity of the doubly closed shell $Z = 50$, $N = 82$ are not very well known, mainly because of the difficulties in producing the isotopes and their short half lives. Some nuclei with Z about 50 and N about 82 can however be produced in fission. In order to study these more thoroughly, an isotope separation is necessary. Work following these lines is being done by the electromagnetic isotope separator group at the Nobel Institute of Physics.

When separating Sn activities, for example, mainly four short lived isotopes have been observed with mass numbers $A = 131\,(T\frac{1}{2} = 1.6$ h); $A = 129\,(T\frac{1}{2} = 1.8$ h), $A = 128\,(T\frac{1}{2} = 65$ m), $A = 127\,(T\frac{1}{2} = 2.6$ h). Half lives of the last two were known earlier in Sn samples, and the mass numbers are here confirmed. Sn isotopes with $A = 131$ and 129 (corresponding to 1 and 3 neutron holes in the double closed shell resp.) are known to have half lives of about a few minutes. Those found here can be interpreted as isomeric states (M4). Such are expected from comparison with other M4 isomers in this region.

G. ANDERSSON and B. JUNG, *Gustaf Werner Institute for Nuclear Chemistry, Uppsala*

Energy levels in even mass thallium isotopes

The neutron deficient even mass isotopes of thallium offer one of the few series of odd-odd nuclei where regular trends of low-lying energy levels can be distinguished. An extension of this systematics has been made by β-spectrometer studies of the earlier unknown 1.41 h Tl^{196m}, 11 min Pb^{194}, 32.8 min Tl^{194m} and 33 min Tl^{194} together with complementary measurements on 2.40 h Pb^{198}, 1.87 h Tl^{198m}, 37 min Pb^{196} and 1.8 h Tl^{196}. All spectrometer sources were prepared by electromagnetic mass separation following synchrocyclotron bombardments of Hg or Tl and standard chemical procedures.

G. ANDERSSON, *Gustaf Werner Institute for Nuclear Chemistry, Uppsala*

A case of fringing field focusing with possible application to electromagnetic mass separation

If a parallel beam of monoenergetic ions enters a homogeneous magnetic sector field at right angles to the field boundary, it can be shown that ions of the same mass will be brought to a coinciding horizontal and vertical focus when the following relation between deflection angle ϕ and sector angle Ω is fulfilled:

$$\operatorname{tg}(\phi-\Omega)=\operatorname{tg}\frac{\phi}{2}.$$

The sector angle can be chosen so that two-directional focusing is realized with good approximation over a considerable mass range. The dispersion compares well with that of a symmetric sector field for the same central beam radius.

L. ASK, *Department of Physics, University of Lund*

Measurement of fluorine gamma rays by a three-crystal scintillation pair spectrometer

A three-crystal scintillation pair spectrometer will be described. It has been used to study the relative intensities of the 6.1, 6.9, and 7.1 MeV gamma rays of O^{16} from the reaction $F^{19}(p, \alpha\gamma)O^{16}$ at different proton energies in the range 1.8–2.5 MeV.

INGER ASPLUND and T. WIEDLING, *Department of Physics, University of Stockholm*

On a zero-spin excited state in Ca^{42}

An angular correlation measurement has been carried out on the 0.3 MeV–1.5 MeV gamma cascade in Ca^{42} in order to determine the spin of the 1.8 MeV level and the multipole character of the 0.3 MeV line. The experimental data were fitted to the Legendre expansion $W(\theta)=1+A_2P_2(\cos\theta)+A_4P_4(\cos\theta)$, giving the constants $A_2=0.33\pm0.04$ and $A_4=1.07\pm0.05$. This result was obtained after application of some corrections taking account of bremsstrahlung, 1.5 MeV gamma coincidences causing smearing out effects on the correlation. The experiment is in good agreement with the theoretical predictions of a 0-2-0 gamma cascade. The 1.8 MeV level, which is a second excited state, has the spin zero according to this measurement. Zero spin excited states have been observed only in a few nuclei up to now.

EKBAL BASHANDY, J. LINDSKOG, P. A. TOVE and T. R. GERHOLM, *Institute of Physics, University of Uppsala*

Studies of the high frequency method for measuring short lifetimes

Present delayed coincidence techniques for short lifetime measurements are limited to lifetimes larger than about 10^{-10} sec. A high frequency method previously suggested[1] at this institute will lower this limit to approximately 10^{-12} sec. In principle the new method works as follows. The source in an electron-electron coincidence spectrometer is connected to a high frequency oscillator. A time difference between two cascading conversion electrons will then be converted into an energy difference. This energy difference is observed as a broadening of the coincidence curve.

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[1] T. R. GERHOLM Ark. f. fysik *11*, 55 (1956).

Theoretical studies as well as experimental results will be presented.

K. E. Bergkvist, *Nobel Institute of Physics, Stockholm*

The use of the axial focusing of the two directional focusing β-spectrometer for the reduction of the background in external conversion measurements

In γ-spectroscopy by means of external conversion the continuous background under the photolines is often very high. This background is made up by several contributions for example a) direct γ-radiation from source to detector, b) scattering of electrons in the spectrometer walls, c) Compton effects in the converter and converter backing and d) Compton and photo effects in the absorber which is generally necessary to have between the source and the converter in order to get rid of internal conversion electrons and β-particles. A method is preposed to reduce the contributions from d) which are generally the predominant ones.

Consider a two directional focusing β-spectrometer with $\beta = 3/8$ (in which case the axial aberration is zero in second order appr.) where the detector slit is screened off in the vicinity of the symmetry plane of the spectrometer to an extent given by the axial size of the source. Thus, electrons coming directly from the source are not detected. The converter, which is large compared with the sample is placed in front of the source. The image of the converter will then essentially fall within the open part of the detector slit and hence photo electrons from the converter are detected. Electrons from the source will be scattered in the converter and might then be able to reach the detector. By making a circular hole in the converter which means cutting off all photoemission angles smaller than a given angle θ_0 it is possible to achieve that only a small part of the electrons from the source is detected without loosing too much in photoline intensity. The reduction of the background depends upon θ_0, the material and thickness of the converter and the converter backing and of the energy.

P. Bergvall and O. Beckman, *Institute of Physics, University of Uppsala*

High precision curved crystal gamma spectrometer

A curved crystal diffraction spectrometer of the Du Mond type is described. The source is fixed while the crystal and detector turn around a common axis. This arrangement has the great advantage of a simple mechanical construction, and the energy measurement is reduced to the determination of an angle of rotation, which can be read off a circular scale to within 0.2″. The crystal is quartz, $(13\bar{4}0)$, 1.5 mm thick and with a free aperture of 15×20 mm^2, bent to a radius of 2 m. The detector is a scintillation counter and a collimator made of tungsten sheet ensures measurements up to 1.2 MeV with no appreciable increase in background. The low energy limit is set by absorption at 20 keV. At 300 keV the counting rate is 200 counts/min for 100 mC source strength and the resolution is 0.5 % for a 0.1 mm wide source. Preliminary measurements in Ir^{192} up to 468 keV have shown very good agreement with previous determinations.

P. BERGVALL and S. HAGSTRÖM, *Institute of Physics, University of Uppsala*

Precision measurements of K and L levels in heavier elements by means of crystal diffraction and photo electron methods

The 2 m curved crystal diffraction spectrometer described in a separate report,[1] has made possible high precision measurements of the K X-ray spectra of elements $Z \geqslant 42$. Determinations of the $K\alpha_1\,\alpha_2$ transition energies have been made in fifth period elements and in all the rare earths with an average accuracy of 0.5 eV. The three L levels of the rare earth elements have also been measured by the photo electron method with the same absolute precision. Excellent agreement has been found for the L_{II}–L_{III} energy difference as obtained by the two methods. For gold, the K absorption edge has been measured by crystal diffraction, taking the "thickness effect" into consideration by using different absorber thicknesses. The K energy value obtained agrees within its error limits, 5 eV, with the mean of the $(K\alpha_1 + L_{\text{III}})$ and $(K\alpha_2 + L_{\text{II}})$ values for this element.

J. BJÖRKMAN, *AB Atomenergi, Stockholm*

Start pulse generator for a time-of-flight analyzer

The open positions of the fast chopper in use at the reactor R1 are timed by a light beam which passes through the rotor slits and produces approximately triangular voltage pulses at the output of a photomultiplier tube. The output pulses from the 8 rotor slits vary about 20 per cent in amplitude. In addition the output signal contains a considerable amount of noise. In order to obtain a reliable start pulse for the time analyzer from these photomultiplier pulses the following circuit has been developed:

The pulses are amplified and the high frequency components of the noise are suppressed by limiting the band width of the amplifier. Then the pulses are fed to a short-circuited delay line in which the triangular pulses are shaped to antisymmetric double pulses. The zero passage of this waveform corresponds to the maximum of the triangular input waveform, though delayed. The delay time is determined by the pulse-forming network and independent of the input amplitude. After further amplification the double pulses are fed to a Schmitt trigger, which generates an output pulse corresponding as closely as possible to the zero passage mentioned above. The start pulse for the time analyzer is derived from this trigger pulse. In this way most of the time jitter due to the imperfect photomultiplier pulses is eliminated.

J. BLOMQVIST and S. WAHLBORN, *Nobel Institute of Physics and Division of Mathematical Physics, Royal Institute of Technology, Stockholm*

Shell model calculations in the lead region with a diffuse potential

With the use of a diffuse potential of the Saxon type, including a spin-orbit interaction, numerical solution of the single nucleon Schrödinger equation has been performed for different values of the potential parameters. The energy eigenvalues have been corrected for collective and pairing effects, and the potential parameters have been determined by a comparison of the corrected energies with the experimental level schemes of the four nuclei, which differ from the double-magic Pb^{208} with one nucleon. The changes of the energies with the potential parameters have been investigated. The obtained radial wave functions will be used for calculation of different matrix elements.

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[1] P. BERGVALL and O. BECKMAN (this conference).

B. BONNEVIER, *Department of Electronics, Royal Institute of Technology, Stockholm*

Experiments on the confinement of an electron gas in a magnetic field

The confinement of electrons in different types of magnetic "bottles" is studied experimentally. A cathode is placed inside the confinement region and the electron current to the surrounding walls is measured as a function of the magnetic field strength. Toroidal and mirror-shaped fields are examined as well as the field generated by a current loop as suggested earlier by Lehnert (Nature, *181*, 331, 1958). In particular, it is shown that the cut-off of the total current is controlled only by the poloidal part of the magnetic field.

S. BRIMBERG, *ASEA, Västerås*

Fast and thermal neutron fluxes in a subcritical reactor in the presence of a neutron source of intermediate energy

In a stationary subcritical spherical reactor with reflector is placed a neutron source (Sb + Be, $E_n = 30$ keV), which is approximated with a point source at the origin of the sphere; its mathematical representation is a Dirac delta function. With the help of the Fermi age equation for the fast neutrons and the diffusion equation for the thermal neutrons, the thermal flux is calculated. The lattice constants, which must be used in the numerical evaluation of the results, introduce certain uncertainties in the determination of the flux, and these are discussed. Further, the approximation of putting the source neutrons at fission energy instead of at 30 keV is investigated.

O. BRULIN and S. HJALMARS, *Institute of Theoretical Physics, University of Stockholm and Division of Mechanics II, Royal Institute of Technology*

The gravitational zero mass limit of spin-2 particles

A Dirac equation of spin-2 is constructed, which in a suitable zero-mass limit gives the linearized Einstein equations for the gravitational field in the general gauge. In this Dirac equation the elements of the wave function column are the independent components of a 5-dimensional tensor of third rank with one antisymmetrical index pair and with vanishing cyclic permutations. The four matrix coefficients of the momenta are reducible, but form together with the matrix mass term an irreducible matrix system. The coefficients and the mass term are constructed explicitly by means of the infinitesimal operators of the affine 5-dimensional group. The relevant wave function elements are identified with the deviations of the metric tensor components from their normal values, and with the superpotentials of gravitational theory.

N. BÄCKLUND, *Department of Physics, Royal Institute of Technology, Stockholm*

Thermal and electrical conductivity of some iron alloys at low temperatures

An apparatus of "longitudinal steady heat-flow type" has been constructed, suitable for measuring the thermal conductivity of metals at temperatures below room temperature. Using liquid oxygen, solid carbon dioxide and ice as cooling agents measurements of thermal and electrical conductivity have been performed on binary iron alloys containing up to 3 atomic per cent of manganese, nickel or silicon. Electrical resistivity measurements have been made also in the liquid-helium temperature region. The results will be discussed in relation to the Wiedemann-Franz-Lorenz law. Curves of $1/\lambda_e$ versus $1/T$ are found to be slightly curved lines converging towards a point on the high temperature side (λ_e being the electronic part of the thermal conductivity).

G. BÄCKSTRÖM, O. BERGMAN, J. LINDSKOG and J. BURDE, *Institute of Physics, University of Uppsala*

The decay of Au^{194}

The positron spectrum and the internal conversion spectrum emitted in the decay of Au^{194} to Pt^{194} have been investigated by means of double focusing spectrometers. Most of the 300 conversion lines observed have been measured with a resolution of approximately 0.2 %. One hundred transitions were identified as belonging to the decay of the isotope 194, and their energies have in most cases been measured with an accuracy of two parts in 10^4. The relationships between the lines were investigated by means of (e, e)-coincidences with a double lens spectrometer. Ninety transitions could be put into a decay scheme in a reasonably unique way mainly on the basis of energy data. The question of random energy relationships has been investigated statistically. The coincidence data lend support to this part of the decay scheme and makes possible the location of additional transitions. Some evidence has been found for the existence of $0+$ and $4+$ states of collective origin.

G. BÄCKSTRÖM and A. BÄCKLIN, *Institute of Physics, University of Uppsala*

A versatile automatized double focusing spectrometer to be used for neutron capture studies at the reactor R 2

The instrument basically consists of a 50 cm radius double focusing magnet, capable of focusing electrons of energies up to 12 MeV. When the spectrometer is used with a collimated gamma beam Compton electrons are detected in coincidence with back-scattered photons. Alternatively, photo-electrons may be recorded in coincidence with the X-rays produced in the converter foil. The instrument is also to be used with collimated neutrons, in which case internal conversion of prompt gamma rays may be studied. A rotating coil device measures the magnetic field, the error signal being used to regulate the current of the magnet by means of series transistors. The spectrometer will operate fully automatically.

I. CARLVIK and B. PERSHAGEN, *AB Atomenergi, Stockholm*

Calculations of effective surfaces for resonance capture of neutrons (The Dancoff-Ginsburg correction factor)

The common method of computing the resonance escape probability in a heterogeneous nuclear reactor lattice uses an effective resonance integral which is generally divided into a volume term and a surface term. The latter is proportional to the surface to mass ratio of the fuel lumps. When the lumps are closely spaced, they shadow each other, and one has to use an effective lump surface that is smaller than the actual surface. For calculation of this surface correction the following simple physical model is used. 1) The volume occupied by the moderator has a constant source density of resonance neutrons. 2) One collision between a resonance neutron and a moderator atom throws the neutron out of the resonance region. 3) The fuel lumps are black to resonance neutrons. Using this model we have developed formulae and calculated correction factors for several interesting geometries.

MATHILDE DE CROËS and G. BÄCKSTRÖM, *Institute of Physics, University of Uppsala*

On the decay of Se^{75}

The decay of Se^{75} (120 d) to As^{75} has been investigated by the use of a 50 cm radius double focusing spectrometer. Transition energies were determined relative to standard lines in Au^{198} and Au^{199} and found to be (in keV) 24.48, 65.98, 80.75, 96.70, 121.02, 135.89, 198.55, 264.42, 279.22, 303.71, 400.34. Apart from these transitions, which have also been reported by other workers, two new transitions of 188.40 and 203.02 were found.

Conversion coefficients have been measured by means of the scintillation and photo-electron techniques. Special attention has been paid to the possibility of an Eo admixture of the 265 keV line, which connects states of probably similar character $(\frac{3}{2}-)$.

A. DATTNER, *Department of Electronics, Royal Institute of Technology, Stockholm*

Acceleration of plasma

A gas discharge between two coaxial cylinders is studied with pulsed discharge current of the order of 10^4–10^5 A. Acceleration of the plasma in the discharge is measured by means of photocells. The current distribution in the plasma is investigated with magnetic coils. The results are compared with calculations based upon a "snow plow" model of plasma motion and a fairly good agreement is found for the case of hydrogen.

E. DJURBERG, *Department of Electronics, Royal Institute of Technology, Stockholm*

Some power supply problems encountered in connection with short-time tests using large magnetic energies

A discussion of the general problems associated with the generation and the regulation of large amounts of energy in magnetic circuits.

An outline will be presented of tests using a dc–generator of a short time rating 8000 A, 1000 V during 3–4 sec. The test run is initiated through the closing of a switch between the generator terminals and the winding of the fission vessel; prior to the switching the generator is magnetized to its rated voltage value. When appropriate winding current is reached and the desired plasma measurements have been made, the winding current is decreased by the application of a counter voltage of the generator field of the order of 7 times normal voltage and by the insertion of a high power damping resistor in the main circuit.

J. Dubois, *Department of Physics, Chalmers University of Technology, Gothenburg*

Virtual states in V^{47} obtained by proton bombardment of Ti^{46}

Excitation functions for charged-particle-induced reactions on light elements have been thoroughly investigated during the last decade. It is of interest to perform similar measurements on nuclei of intermediate masses. Here one expects, however, closely spaced levels and low yields owing to the large coulomb barriers. Accordingly, one must have good energy resolution, comparatively great beam intensity and sensitive detectors with low background.

An electromagnetically separated Ti^{46} target was bombarded by protons with energies of 700–1700 keV from the Van de Graaff generator at Gothenburg. Forty radiative capture resonances were observed.

E. Dyring, *Institute of Physics, University of Uppsala*

Estimation of the standard deviation of the two international standard instruments for cosmic ray intensity measurements

During the International Geophysical Year 1957–58 a cosmic ray station has been running at Murchison Bay, Svalbard (80°02′ N., 18°18′ E.). The station was equipped with the two international standard instruments, one neutron monitor, one international cube plus one East-West directed telescope.

The registration of the two standard instruments has been used for an estimation of the standard deviation of the results. Both instruments are divided in two equal halves, and the differences of the uncorrected data have been used to eliminate the time variation of the cosmic ray.

The results show for the neutron monitor 15 % higher, and for the international cube 35 % higher standard deviation than the normal used, $\sqrt{N}$ (N = counting rate), as an estimation of the error of cosmic ray measurement.

G. Ekspong and B. Ronne, *Institute of Physics, University of Uppsala*

Antiproton-nucleon cross sections in the energy region 20–250 MeV

The interaction properties of antiprotons with nuclei in photographic emulsions have been studied in the energy region 30–250 MeV. A path length of 37 meters has been followed on the 374 antiprotons found during the scanning. Observation of elastic scattering on free protons have yielded a cross section of 77 ± 17 mb at an average energy of 170 MeV in good accord with the theory of Chew and Ball. The differential scattering cross section on free protons is peaked forward. The interaction mean free path of 18.3 ± 1.3 cm has been analysed to give an annihilation cross section of $98 \pm^{30}_{25}$ mb at the average energy of about 150 MeV. The effect of the Pauli exclusion principle on the scattering on bound nucleons has been treated theoretically. The cross section for inelastic scattering on complex nuclei is low and found to be 43 ± 11 mb, which is consistent with a simple, optical model calculation. The elastic scattering on complex nuclei is mainly Rutherford and diffraction scattering.

B. ENANDER, *Department of Electronics, Royal Institute of Technology, Stockholm*

Experiments on microwave propagation in a plasma-filled coaxial line

The microwave propagation in a coaxial line with a gas discharge between the inner and outer conductor has been investigated. A magnetic field has been applied in the direction of the line. The experiments, which have been carried out at frequencies from 100 MHz to 7000 MHz, show that there is a very broad absorption band around the gyromagnetic frequency. This band usually extends from the gyromagnetic frequency up to a higher frequency which can be several times the gyromagnetic frequency.

J. ERICSSON and L. JOHANSSON, *Institute of Optical Research, Royal Institute of Technology, Stockholm*

A new interferometric technique for examining spectral line broadening

A shearing interference method of determining spectral line widths and shapes from the visibility curve of two-beam interferences as a function of the path difference between the interfering wavefronts has been tried. The visibility is the Fourier transform of the intensity curve of the spectral line. In each measurement a limited number of points of the visibility curve is determined, this being sufficient to give the whole curve if the points are properly chosen. The image is preferably registered by a photographic plate which is then measured in a microdensitometer. Hence light sources of very low intensities can be investigated. Two slightly different shearing interferometers have been used, one with a Savart plate combined with an entrance slit and the other with a Wollastone-type compensating prism for large apertures. In the latter case no entrance slit is necessary, and combinations with a wide band monochromator can be made without any serious loss of intensity.

K. B. ERIKSSON and I. JOHANSSON, *Department of Physics, University of Lund*

The spectrum of the neutral nitrogen atom in the wavelength region 1–3 μ

An investigation of the nitrogen spectrum has recently been published by Eriksson (Arkiv för Fysik, *13*, 429 (1958)). This investigation is now being continued in the lead-sulfide region by using a hollow-cathode discharge as a light source. It is intended to record the spectrum by means of a high-frequency electrodeless discharge as well. Up to the present we have obtained accurate energy values for some doublet levels and a definite connection between the doublet and quartet systems. This makes it possible to calculate new accurate wavelengths for use as standards in the Schumann region.

U. ERICSSON, *Research Institute of National Defence, Stockholm*

On shock fronts with radiative loss

The Rankine-Hugoniot equations for the flow of mass, momentum and energy through a gas shock front are extended to include radiative energy loss. Such a loss is significant at high gas velocity in the shock and low density ahead of the shock. The radiative cooling does not affect the relation between shock pressure and gas velocity significantly, but changes the relative density in the shock front from the the order of 10 to the order of 10^2 or 10^3.

The equations are applied to hot air shocks. At temperatures between 10^6 and $2 \cdot 10^6$°K selective absorption in the cool air ahead depresses the relative density to normal.

INGA FISCHER-HJALMARS, *Institute of Theoretical Physics, University of Stockholm*

The lowest energy states of the negative hydrogen molecule ion H_2^-

The potential energy curves for the lowest states of H_2^- have been calculated for a series of values of the internuclear separation R ranging from 0.5 to 5 Å. For the ground state $^2\Sigma_u^+$ an energy minimum has been found at $R = 0.9$ Å, corresponding to a dissociation energy of $2.5 \text{ eV} = 59 \text{ kcal/mole}$. H_2^- is thus found to be comparatively stable towards dissociation into H and H^-. On the other hand the electron affinity of H_2 is found to be negative, $EA(H_2) = -0.3$ eV, thus being intermediate between $EA(He) = -0.5$ eV and $EA(H) = +0.75$ eV.

The following excited states, arranged according to increasing energy values, have been found to correspond to discrete energy levels: $^2\pi_u$, $^2\Sigma_g^+$, $^2\Sigma_u^-$ and $^4\Sigma_u^+$. All these levels are found to be rather close together, approximately as the triplet states of H_2. This close spacing of the levels is supposed to be a general feature of negative molecular ions.

By use of the theoretical results for H_2^- a tentative explanation is given of the experimental results, obtained recently by Khvostenko and Dukelsky[1] in a study of collisions between electrons and hydrogen molecules.

S. FLODMARK, *Department of Theoretical Physics, University of Stockholm*

Energy bands in the MB_6 crystal

A solid state treatment has been performed by the present author for metal borides of MB_6 type.[2] Special interest has been put into the boron atomic orbitals of *d* type, although these orbitals do not contribute to the ground state of free boron. Since it is necessary to cut off the interaction terms for a reasonable order of neighbours, it is however, very difficult to reach reliable values for the d orbital contribution on account of their great overlap. For Slater d orbital exponents the approximate treatment gave secular equations with indefinite overlap matrices. This inconvenience is removed by using higher d orbital exponents. Now numerical computations of the energy bands are going on for different choices of the d orbital exponents.

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[1] V. I. KHVOSTENKO and V. M. DUKELSKY, Sovjet Physics JETP *6* (33), 657 (1958); Zh. eksper. teor. Fiz. *34* 1026, (1957).

[2] S. FLODMARK, Ark. Fys. *14*, 513 (1959).

B. FORKMAN and S. A. E. JOHANSSON, *Department of Physics, University of Lund*

Angular distributions in photofission of uranium

The angular distributions in photofission of natural uranium have been measured. Bremsstrahlung with maximum energies of 10 and 20 MeV and monoenergetic gamma rays of 6.1, 6.9 and 7.1 MeV energy have been used as gamma ray sources. The fission fragments have been detected in two ways. One method has been to irradiate nuclear emulsion containing uranium. In the other method a scintillation counter is used to count the fission fragments. The first method is more tedious but has a better angular resolution. The two methods give results that agree very well.

The following results have been obtained. The angular distribution at 6.1 MeV is of the form $\sin^2\theta + 1.5 \sin^2\theta \cos^2\theta$. At 6.9 MeV the angular distribution is mainly isotropic but contains a small $\sin^2\theta$ term. At 7.1 MeV it is isotropic. The angular distribution obtained with 10 MeV bremsstrahlung is of the form $1 + 0.73 \sin^2\theta + 0.18 \sin^2\theta \cos^2\theta$. With 20 MeV bremsstrahlung the angular distribution is isotropic.

The results are compared with the theory of A. BOHR. They seem to agree very well with the theory.

Å. FRISK, G. EKSPONG and B. RONNE, *Institute of Physics, University of Uppsala*

Emission of a ${}_{\Lambda}H^4$ hyperfragment from an antiproton capture star

In the antiproton annihilation process there are produced a number of pimesons. Sometimes also strange particles are created. In emulsion work several certain K-mesons have been reported but no definite example of the emission of a hyperon or a hyperfragment. During the analysis of antiprotons in nuclear emulsions we have found an annihilation in which a ${}_{\Lambda}H^4$ hyperfragment is emitted. The hyperfragment comes to rest in the stack and decays into a negative pimeson and an α-particle. From the kinetic energies of the decay products and the masses involved we can calculate the binding energy of the lambda hyperon with the result: (2.5 ± 1.0) MeV.

T. R. GERHOLM, *Institute of Physics, University of Uppsala*

Conversion matrix elements in Tl^{203} and Tl^{201}

As pointed out by Church and Weneser[1] the conversion matrix elements are not necessarily strictly proportional to the electromagnetic matrix elements. The ratio of the conversion matrix element M_e to the electromagnetic matrix element M_γ depends on the details of the nuclear structure. Particularly large ratios are expected in the case of l-forbidden M1 transitions. In this case the theory indicates $\lambda = M_e/M_\gamma \geqslant$

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[1] E. L. CHURCH, and J. WENESER, Phys. Rev. *104*, 1382 (1956).

10. λ can be determined from the conversion coefficient as well as from gamma-electron angular correlation measurements. A comparison between these two measurements serves as a check on the theory of internal conversion.

Experimental results recently obtained at this institute[1,2] will be presented. In the case of Tl^{203} the experiments indicate $4 < \lambda < 6$ and for Tl^{201} a preliminary value of $\lambda \approx 5$ has been determined. The detailed analysis depends on particle parameters now being computed.

Z. Grabowski, B. van Nooijen and I. Marklund, *Institute of Physics, University of Uppsala*

Two 0+ states in Os^{188}

Directional correlation measurements of three cascades in Os^{188} from Re^{188} have given the following correlation coefficients:

931–155 keV	$A_2 = +0.276 \pm 0.012$	$A_4 = +0.930 \pm 0.025$
673–633 keV	$A_2 = +0.068 \pm 0.008$	$A_4 = +0.017 \pm 0.018$
828–633 keV	$A_2 = +0.295 \pm 0.009$	$A_4 = +0.015 \pm 0.020$
1133–633 keV	$A_2 = +0.37 \pm 0.03$	$A_4 = +0.92 \pm 0.07$

The spins of the levels 1086, 1306, 1461 and 1765 keV are determined to 0+, 2+ (or 4), 2− and 0+. The 1086 keV level seems to be the first member of the beta vibrational band, and the second 0+ level may arise from a two phonon beta vibration or from two particle excitation.

R. Grahn, *Department of Theoretical Physics, University of Stockholm*

A Theoretical investigation of the role of polarization in the formation of hydrogen bonds[3]

The purpose of the investigation was to investigate the question of whether polarization energies ought to be taken into account when calculating hydrogen bond energies. Therefore the aim has been to get only the correct orders of magnitude, and not quantitative information, concerning these energies.

Of course, the influence from polarization cannot be strictly separated from other contributing effects, e.g. electrostatic and covalent binding. If the effects are "small", however, such a separation may be justified. We have under this assumption treated four cases: H_2O, HF, H_2S and HCl. Systems of the form $O–H \cdots O$ and similar for the three other cases have been considered.

For H_2O and HF, the molecules of which form strong H bonds, the polarization energies were found to be of the same orders of magnitude as the total H bond energy. For H_2S and HCl, the molecules of which form no, or very weak, H bonds, the polarization energies were found to be negligible compared with the energy of a normal H bond.

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[1] B.-G. Pettersson, B. van Nooijen, Z. Grabowski and T. R. Gerholm (to be published).

[2] J. Lindskog, E. Bashandy and T. R. Gerholm (to be published).

[3] R. Grahn, Ark. Fysik *15*, 257 (1959).
I. Fischer-Hjalmars and R. Grahn, Acta Chem. Scand. *12*, 584 (1958), (preliminary report).

P. GUNNVALD, *Department of Physics, University of Lund*

Photoelectric device for measuring spectrograms

A device for making comparator settings by photoelectric scanning of spectrum line images is described. The device is readily adaptable to comparators of the fixed microscope-moving plate type. The eye piece of the microscope is used to focus the spectrum line images on a fixed slit in front of a photomultiplier tube. Scanning is accomplished by interposing a rotating plane-parallel plate between the eye piece and the slit. The fiducial position is determined by matching mirror image oscilloscope traces of the line contour. This method of setting has the advantages of increased speed, precision, objectivity of setting and decreased eye strain on the operator.

R. K. GUPTA, *Nobel Institute of Physics, Stockholm*

On the decay energy measurement of electron-capturing isotopes of thallium

In the determination of the electron-capture decay energy, one has to use indirect methods, as the total disintegration energy is taken away by the neutrino, hardly suceptible for direct measurements. The most common indirect methods used by β-ray spectroscopists are 1) The measurement of inner-bremsstrahlung spectrum, 2) The calculation of P_{L1}/P_K. The first method is very useful, if the γ-rays are not associated with the decay, while a reliable value of the decay energy can be obtained by determining P_{L1}/P_K to the highest excited state of the daughter nucleus from experimental observations.

The P_{L1}/P_K has been obtained by studying coincidences between the highest energy γ-ray and K-Xrays in case of Tl^{202}, Tl^{201} and Tl^{199}. The systematics of decay energy in this region will be presented.

S. HAGSTRÖM, *Institute of Physics, University of Uppsasla*

Quartz crystal point-focussing monochromator used in an apparatus for small-angle scattering of X-rays

A quartz crystal monochromator giving a point-focus is described. A circular lamina (diameter 60 mm, thickness 0.5 mm) of quartz crystal is bent between two concentric circular edges. The shape of the crystal surface is shown to give a point-to point focussing system for a Bragg angle of approximately 80° with the atomic planes chosen $(10\bar{1}0)$. The radiation used is Mn $\mathrm{K}\alpha_1$ with $\lambda = 2.10$ Å. The distance: X-ray source to crystal is 100 cm. The monochromator is used in an apparatus for studying small-angle scattering of X-rays. Investigations are made on the particle size of Dow Polystyrene Latex. The particles have a spherical shape with diameters 0.340 μ, 0.264 μ and 0.138 μ. Further, some exposures have been made on collagen in dry kangaroo-tail-tendon. The camera resolved the central first order of the 640 Å period and is capable of resolving consecutive orders of spacings as high as 10 000 Å.

GUNILLA HAHN, *Nobel Institute of Physics, Stockholm*

An ionization chamber for use in nuclear reaction investigations

An ionization chamber has been constructed for being directly mounted to the target chamber of the heavy particle spectrometer.[1] The ionization chamber was primarily intended as a monitor in experiments with that instrument but can, with suitable electronic equipment, be used as a spectrometer for protons, deuterons or α-particles.

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[1] B. SJÖGREN (this conference).

The mounting to the target chamber has required a special construction. The chamber is mainly a square tube about 25 cm in length. The ionizing particles to be analyzed are let into the chamber through a thin mylar window at one end of the tube, and pass first through a small proportional counter before entering the main ionization chamber. The proportional counter, which makes coincidence arrangements for bringing down background possible, has a 0.05 mm central wire and a cylinder diameter of 20 mm. The ionization chamber is of the gridded type[1] and has the grid and collector parallel with the axis of the tube. The grid consists of 0.1 mm wires separated by 1.0 mm. Its distance is 1 cm from the collector and about 3 cm from the opposite wall of the tube. The preamplifier for the chamber is of the conventional type[2] and it has been mounted directly to the tube. When the counter was filled with pure argon of 0.5 at pressure, the analysis of the 8.8 MeV peak in the α-spectrum of a ThC-sample resulted in a width at half maximum of about 120 keV. Work to improve this figure is going on.

Some examples of similar constructions are published in[3] and[4].

J. Hamilton[5] and J. Hollander,[6] *Institute of Physics, University of Uppsala*

Decay of Pa^{233}

A very careful study of the low-lying levels of U^{233} populated by the beta decay of Pa^{233} has been undertaken. Albridge, Gallagher, and Hollander (private communication) have measured the intensities and energies of the photons with a bent crystal spectrometer and investigated the conversion electron spectrum in permanent field spectrographs. They also measured the absolute K conversion coefficient of the strongest transition ($E\gamma = 311.9$ keV).

There remained some inconsistencies, however, in the theoretical interpretation of the levels. Additional data on the intensities of certain conversion electron lines were needed. The conversion electron spectrum from the beta decay of Pa^{233} has been measured with high resolution in an iron-free, double focussing spectrometer. These data were combined with the work mentioned above to yield absolute conversion coefficients for ten of the transitions. Multipole mixing ratios have been assigned for the transitions. The photon and electron intensities indicate five beta groups instead of three as previously reported. The inconsistencies were essentially all removed and a more complete decay scheme worked out.

$\beta - \gamma$ directional correlations were carried out with the 312 keV gamma ray. A maximum anisotropy of $\lesssim 5\%$ was observed.

Britt Hartmann, *Research Institute of National Defence, Stockholm*

Measurements of Faraday effect in germanium

The free carrier Faraday effect has been studied in the wavelength region 1.8–7 μ, in n-doped germanium with high carrier concentration. The Faraday rotation near the absorption edge has been investigated in pure germanium specimens of various thicknesses. The results are discussed in relation to the theoretical expressions for Faraday rotation produced by free and bound carriers in semiconductors.

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[1] Wilkinson, Ionization chambers and counters. Cambridge press (1950).

[2] B. Åström, Arkiv för fysik *12*, 215 (1957).

[3] Fulbright, Lassen and Poulsen, Mat. Fys. Medd. Dan. Vid. Selsk. *31*, 7 (1959).

[4] Handbuch der Physik XLV, 46.

[5] National Science Foundation Fellow on leave from Vanderbilt University.

[6] Guggenheim Fellow on leave from University of California.

L. Hedin, *Division of Mathematical Physics, Royal Institute of Technology, Stockholm*

Elastic constants and atomic parameters

The relation between elastic constants and atomic parameters has been derived by Born and Huang applying the method of long waves in an infinitely large solid.

Considering a homogeneous deformation of a lattice with finite dimensions we confirm the Born-Huang relations and show their range of validity. If the lattice possesses a finite homogeneous strain we use linearized elastic constants, the properties of which are derived in an appendix.

The concept of the atomic potential energy is discussed.

E. Hellstrand and J. Weitman, *AB Atomenergi, Stockholm*

Experimental determination of the effective resonance integral for thorium metal rods

The effective resonance integral of thorium metal rods of different diameters has been determined as a function of the surface to mass ratio for cylindrical rods. The diameters investigated range from 4 to 25 mm.

The cadmium covered thorium rods were irradiated in the central channel of the Swedish reactor R1, and the induced Th^{233} activity in suitable samples was measured in a β-sensitive scintillation counter. The specific acitivities normalized to unit neutron flux were calibrated by a comparison with the activity from thin gold foils, irradiated under the same conditions as the thorium rods. To account for the different detector sensitivities for the two activities, an irradiation of the thorium and gold samples was also made in the thermal column of the reactor. As the thermal cross sections for thorium and gold are known as well as the true resonance integral for gold, the effective resonance integral of thorium could then be obtained.

C. J. Herrlander, R. Stockendal and R. K. Gupta, *Nobel Institute of Physics, Stockholm*

The decay of Tl^{201}

The decay of Tl^{201} has been studied in a double-focusing β-spectrometer and a β–γ coincidence spectrometer of intermediate-image type. The energies and conversion ratios of the previously known M1-transitions of 30.6, 32.1, 135.3, and 167.4 keV[1] have been remeasured with a higher accuracy. A determination of the conversion coefficients for the 135.3 and 167.4 keV transitions also proved these to be M1-transitions.[2] A new transition with an energy of 165.8 keV has been found and classified as M1. No other transition with an energy <600 keV was observed.

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[1] K. E. Bergkvist, I. Bergström, C. J. Herrlander, S. Hultberg, H. Slätis, E. Sokolowski, A. H. Wapstra, and T. Wiedling, Phil. Mag. *46*, 65 (1955).

[2] R. Stockendal, this conference.

In the β–γ coincidence experiments the earlier results were confirmed: the 30.6 and 32.1 keV transitions are both in coincidence with the 135.3 keV gamma ray, but not with the 167.4 keV gamma ray. The 135.3 and 167.4 keV gamma rays are not in coincidence with each other.

In agreement with the earlier measurements[1] the excited levels in Hg^{201} have the energies 1.5, 32.1, and 167.4 keV. Because of the new 165.8 keV transition, the spin assignments have to be revised.

C. HERRLANDER and H. SLÄTIS, *Nobel Institute of Physics, Stockholm*

Intermediate image coincidence beta-ray spectrometer

Two β-ray spectrometers of a new intermediate image type[2] have been built and mounted coaxially in such a way that the two spectrometers can be used either separately or for e^-–e^--coincidence measurements. In order to make such measurements possible the source has to be placed outside the iron yokes, axially between the spectrometers. The shape of the magnetic field necessary for this arrangement has been investigated. Data for the resolution and transmission are given.

H. HERTZ, *Department of Physics, University of Lund*

A new dose-rate meter for X-rays

A new dose-rate meter of very small dimensions has been constructed using a pn-junction in a GaAs semiconductor. Because of its special cylindrical form the dependence on X-ray energy is relatively small in the energy range normally employed in X-ray therapy. Compared with conventional dose meters the new element is much smaller (diameter 2 mm), has relatively low impedance, and a fast response which makes it well suited for control measurements during X-ray therapy. Its sensitivity is about 10^{-7} A at 100 r/min.

MONICA HESSLER, *Institute of Theoretical Physics, University of Stockholm*

On nonlocal effects in weak interactions

The weak interactions are assumed to be slightly nonlocal, corresponding to an interaction Hamiltonian of the following form, using the V–A coupling supposed by Feyman & Gell-Mann,

$$H_I = \sqrt{8}\, g \iint [\bar{\psi}_1(x)\gamma_\mu a \psi_2(x)] \frac{e^{-\frac{|\vec{x}-\vec{x}^1|}{l}}}{|\vec{x}-\vec{x}^1|} [\bar{\psi}_3(x^1)\gamma_\mu a \psi_4(x^1)]\, d^3x^1\, d^3x$$

i.e. the fermions interact in pairs and the interaction between the pairs is propagated by a heavy boson, which gives rise to a Yukawa potential when eliminated from the Hamiltonian. The effects in β- and especially μ-decay are considered. It is found that the nonlocality increases the ϱ-value above 0.75. The experimental value, 0.74 ± 0.03, sets an upper limit of $\approx 10^{-13}$ cm for the characteristic length l, which corresponds to a boson mass of $\approx 400\, m_e$.

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[1] Se not 1, sid. 16.

[2] H. SLÄTIS and C. J. HERRLANDER, Rev. Scient. Instr. *26*, 613 (1955).

The coupling constant used above is related to the constant G of the local theory by $G = 4\pi l^2 \cdot g(l - k \cdot l^2)$. This means that g has the dimension of charge in contrast to G, and that the experimentally determined value of G does not tell the strength of the coupling until l is known. The l-value given above gives $g \geqslant 10^{-24}$. This can be compared with the strength of the electromagnetic interaction which is $\approx 10^{-19}$.

G. Hettinger, K. Lidén and N. Starfelt, *Radiation Physics Department, University of Lund*

Scattered radiation in water irradiated by photons between 50 and 250 keV

The spectral distribution of scattered radiation in an irradiated water tank ($30 \times 30 \times 30$ cm^3) was studied with scintillation spectrometer technique. In order to reduce the K X-ray escape fraction a well-type NaI(Tl)-crystal was used. The primary semi-monoenergetic radiation was obtained from an X-ray generator supplied with heavy filters. The angular components of the photon and dose buildup were calculated from the experimental results at different depths. The determined spectra, differential in energy and angle, were integrated over all angles to give the photon number flux. Within the energy range studied the photon buildup was found to be nearly independent of the primary energy.

R. Hoffman and S. Gronowitz, *Institutes of Physics and of Organic Chemistry, University of Uppsala*

The coupling of nuclear spins by hyperconjugation

The proton magnetic resonance spectra of several unsaturated organic compounds have been studied under high resolution. In all cases studied, protons in methylgroups (or methyl-like groups such as CH_2Cl–) have spin-spin interactions exceeding 1 c/s over the double (or triple) bond to protons at four or more bond distances from the methyl protons.

In (trans-)crotonaldehyde the coupling of protons separated by four bonds (two of which are carbon-carbon bonds) is found to be negative, whereas in tiglaldehyde where the protons are separated by five bonds (three of which are carbon-carbon bonds) the coupling has been shown to be positive.

From the results obtained, the following conclusions are suggested:

1. A methyl group proton has a coupling to the π-electrons on the attached carbon atom of the same strength as that of a hydrogen directly attached to the unsaturated carbon atom.
2. The coupling of methyl groups via a triple bond is approximately twice as strong as the coupling via a double bond.

L. Huldt, *Institute for Optical Research, Royal Institute of Technology, Stockholm*

Optical methods for studying electron recombination in semiconductors

The absorption of an electromagnetic energy quantum in a semiconductor may result in an excitation of an electron either (1) over the energy gap E_g if $h\nu > E_g$, thus leading to photoconductivity, or (2) between different energy levels within the conduction band (free electrons) within the valence band (holes). A thermal distribution of the excess electrons (holes) within each band will be obtained in a very short time ($\sim 10^{-10}$ sec). The reestablishment of the inter-band equilibrium distribution, i.e. the recombination of free electrons with holes, takes a much longer time (10^{-7}–10^{2} sec) and, in addition, this time varies considerably with the structure and purity of the material. This recombination can be investigated using intermittent light excitation and the measurement of the induced infrared emission or absorption.

S. Hultberg, R. Stockendal and B. Johansson, *Nobel Institute of Physics, Stockholm*

Applications of a new method for the absolute determination of internal conversion coefficients

The recently reported method[1] of determining internal conversion coefficients absolutely by comparing conversion lines and photolines, has been applied to transitions in the decays of Cs^{137},[1] Bi^{205} and Bi^{206},[2] Bi^{203}, Bi^{204} and Pb^{203},[3] and Tl^{201}.[4] The accuracy has varied between 6 % and 50 %, depending mainly upon the degree of complexity of the spectra. The method has also been used in the reverse sense for the absolute determinations of K-shell photoelectric cross-sections for uranium by application to the wellknown E2-transitions in Ni^{60}.[5] The agreement with the tabulated values of White is within 5 %. Sources and converters of different size and form have been tried (cf. ref. [6]). Very recently, experiments have been performed with the purpose to lower the Compton background in the external conversion measurements.[7] A thin scintillator and a light-guide were placed between the converter and the source and mounted on a photomultiplier tube. Using anticoincidence techniques a decrease of, in some cases, 70 % of the background was observed, while the photoline intensity remained the same.

E. Hulthén, N. Johansson and L. Koffman, *Department of Physics, University of Stockholm*

The vibrational states of $^3\pi_1$ in iodine chloride

The vibrational states of $^3\pi_1$ in ICl^{35} and ICl^{37} have been investigated from the absorption spectrum corresponding to the transition $^1\Sigma^+ \rightarrow {}^3\pi_1$.[8] Several remarkable features appeared among the vibrational frequencies and the rotational constants in the extensive progression of bands belonging to this transition.

Thus the vibrational term values $G(u)$ and $G^i(\varrho u)$ in ICl^{35} and ICl^{37}, $\varrho = 0.978595$, deviate increasingly from each other for $u > 26.5$. The Λ-splitting increases regularly with u and becomes large and irregular in the region around $^3\pi_0(0)$.

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[1] S. Hultberg and R. Stockendal, Arkiv för Fysik *14*, 565 (1959).
[2] R. Stockendal and S. Hultberg, Arkiv för Fysik *15*, 33 (1959).
[3] R. Stockendal, to be published in Arkiv för Fysik.
[4] C. J. Herrlander, R. Stockendal and R. K. Gupta, this conference; to be published in Arkiv för Fysik.
[5] S. Hultberg and R. Stockendal, Arkiv för Fysik *15*, 355 (1959).
[6] S. Hultberg, Arkiv för Fysik *15*, 307 (1959).
[7] B. Johansson and R. Stockendal, to be published.
[8] E. Hulthén, N. Johansson and U. Pilsäter, Arkiv f. Fysik, *14*, 31 (1958).

Finally, the progression of $G(u)$ terminates with $u = 35.5$, however, prolongated by some additional states which are here occasionally numerated as 35.5, 36.5 and 37.5. These levels are decidedly out of course with the main progression.

L. Högberg, K. Siegbahn and K. Bockasten, *Institute of Physics, University of Uppsala*

Electrodeless generation and acceleration of ringshaped plasmoids

A small apparatus is described, designed to study various aspects of electrodeless generation and acceleration of circular plasmoids by shooting a toroidal discharge out of and away from its primary. The maximum primary current is of the order of 100 kA at a ringing frequency of 0.8 Mc/s. The setup also includes a solenoid for a "guiding" magnetic field with field strengths up to 5000 gauss. Some electrical and spectroscopical measurements made with the apparatus are discussed.

T. Högberg, *AB Atomenergi, Stockholm*

Monte Carlo calculations of neutron thermalization

The slowing down of neutrons in a heterogeneous system (a slab geometry) of uranium and heavy water has been investigated by Monte Carlo methods. Effects on the neutron spectrum due to the thermal motions of the scattering and absorbing atoms are taken into account. It has been assumed that the speed distribution of the moderator atoms are Maxwell-Boltzmann in character.

K. Jirlow and E. Johansson, *AB Atomenergi, Stockholm*

The resonance integral of gold

The resonance activation integral of gold has been determined by means of cadmium ratio measurements of thin foils in a neutron beam. Comparison was made with a 1/v-detector, and the neutron spectra were measured with a chopper.

An experimental value of 1490 ± 40 barns was obtained for the resonance integral defined as

$$\int_{0.5}^{\infty} \sigma_r(E) \frac{dE}{E}$$

where $\sigma_r(E)$ is the difference between the total absorption cross-section and the 1/v-part. The resonance integral has also been computed from resonance parameter data with the result 1529 ± 70 barns.

B. Johansson and T. Alväger, *Nobel Institute of Physics, Stockholm*

Preliminary results from measurements of short half-lives with a high-frequency deflection method

A new method for measuring half-lives of excited states in the region $<10^{-10}$ s, based on high-frequency deflection of conversion electrons, has been tested. The method is described by B. Johansson and T. Alväger in "Nuclear Instruments" 3, 49–51 (1958).

The test arrangement has given a resolving time of $3 \cdot 10^{-10}$ s with a slope of the resolution curve corresponding to a half-life of $3 \cdot 10^{-11}$ s. These figures are about ten times better than can be obtained for corresponding energies with other direct methods. The measurements were carried out with a Bi^{206} source in which the cascade 398 keV–184 keV was used. The source strength was about 100 μC. With a higher frequency (144 Mc/s is uesd in the actual case), the figures above for the test arrangement can be improved by a factor of 5 to 10. The optimum resolving time for the method seems to be about 10^{-12} s.

In order to increase the coincidence counting-rate a multi-detector system was built and is being tested. It contains 5 photomultipliers which are connected by light-pipes to 15 plastic scintillators.

One of the photomultipliers is connected to all the scintillators, while each of the other four photomultipliers is connected to seven of the scintillators. By a coincidence system it is possible to determine from which scintillator the light-pulses originate.

B. Johansson and H. Ryde, *Nobel Institute of Physics, Stockholm*

Detector equipment for high counting rate in a double focusing beta-spectrometer

There is often a need for a fast detector system for electrons in a beta spectrometer. This is the case in arrangements for coincidence studies and for external conversion experiments where the photo peaks are often superposed on a high continuous background due to Compton processes.

In the double focusing beta-spectrometer at the Nobel Institute of Physics in Stockholm, a thin plastic scintillator mounted on a RCA 6342 photomultiplier and placed in the center of a Helmholtz coil has been tested as a detector for electrons. A shunted part of the main spectrometer current was sent through the Helmholtz coil in such a direction that the magnetic field was compensated for in the vicinity of the photomultiplier. It was shown that the same shunt setting could be used for the whole measuring region and careful studies of the relative intensities and shapes of conversion lines for different energies indicate that this detector arrangement does not affect these properties.

The detector is intended to be equipped with an acceleration arrangement in order to permit detection also of low energy electrons.

P. Johansson, *Institute of Physics, University of Uppsala*

X-ray excitation states in metals

In a theoretical work "Electronic Band Structure of Solids by the Method of experimental X-ray Spectroscopy" Parratt has recently (June, 1958) criticized the conventional idea of the energy levels in the solid state as well as the interpretation of experimental curves. In acocrdance with this he rejects the common energy level diagram as being incomplete and misleading. With his excitation theory he proposes a new type of diagram, indicating the discrete "bound-ejected-electron" excitation states in which every X-ray level is split. Parratt suggests an experimental test of the existence of these states by studying the position of a K-emission line, when produced by high energy electrons and by electrons near the excitation threshold. A wavelength shift may be expected.

This investigation has been carried out preliminarily with chromium as a target in the X-ray tube. The result indicates a small shift.

R. Johansson and R. N. Varney, *Department of Electronics, Royal Institute of Technology, Stockholm*

Secondary emission from mercury ion bombardment

In this experiment secondary emission of electrons from a graphite target under bombardment of ions from a mercury arc plasma is investigated. The ions are drawn out of the plasma by keeping the target at a negative potential of the order of 3 kV. While in flight some of the ions become fast neutral atoms by the process of charge exchange. Both the neutral atoms and the ions liberate secondary electrons on hitting the target. The total secondary emission is considerably greater than that from the ions alone, particularly at higher voltages and presures.

No ionization by positive ions or neutral atoms was observed. However, since the secondary emission was extremely high, ranging from 2 to 100 per cent of the ion current, small traces of gas ionization would have been undetectable.

S. A. E. Johansson, *Department of Physics, University of Lund*

Single particle effects in nuclear fission

The fission process is usually interpreted in terms of the liquid drop model. The properties of the single particle orbits might in some cases be of importance, however. One such case is the penetration through the fission barrier. The penetration determines the half-life of spontaneous fission. It has been known for some time that even if the general trend of the spontaneous fission half-lives agrees with the drop model, there are very strong deviations. In the present work the influence of the single particle orbits on the barrier height has been calculated using the Nilsson level diagram extrapolated to large deformations. The barrier penetration is then calculated and compared with the experimental spontaneous fission data. It turns out that the deviations from the drop model quite well can be explained as a single particle effect.

Another problem that has been investigated is the coupling between single particle states of different parity. This coupling tends to make the nucleus pear-shaped. For equilibrium deformations this is of importance in connection with the odd parity states of even-even nuclei. In fission it turns out that when the deformation is increased the nucleus reaches a point where the stability against a pear-shaped deformation is lost. This might provide an explanation of the mass asymmetry in fission.

T. Johansson and T. Jonsson, *Department of Physics, University of Lund*

A two-inch bubble chamber

As a first step in a program for large bubble chambers to be used at the 1200-MeV electron-synchrotron at the Departments of Physics, Lund, a small bubble chamber has been constructed. It is cylindrical and has vertical windows. The diameter is 50 mm and the depth 40 mm, making a useful volume of about 80 cc.

The chamber and its auxiliary equipment has been made with a view to test different liquids, especially heavy ones. A dynamical pressure gauge allows the study of the pressure variation in the chamber during operation. In order to obtain tracks of electrons of suitable energy, the chamber is synchronized with the γ-beam from the 35-MeV electron-synchrotron at Lund.

E. KARLSSON and K. SIEGBAHN, *Institute of Physics, University of Uppsala*

High resolution spectrograph studies of separated isotopes

A semicircular β-spectrograph has been constructed. The field is obtained from an electromagnet, which enables all energy regions to be covered. To stabilize the magnet current a transistorized feed-back system is provided which keeps current variations within a few parts in 10^6. A very careful calibration of energies is made by exposing the same recording film to two sources, one with known lines. The film can be exposed by sections along its length which also makes it possible to follow a complex decay without altering measurement conditions.

The spectrograph has been used for studies in the lead region with isotopes from a mass separator. A special technique was developed to make sources suitable for the spectrograph.

B. KLEMAN, *Research Institute of National Defence, Stockholm*

The infrared Faraday effect in semiconductors

The use of Faraday effect (rotation of the plane of polarization of radiation in a magnetic field) to determine the effective mass of charge carriers in semiconductors is discussed. In particular, the experimental technique used to measure the Faraday effect in the infrared wavelength region is described. Some preliminary results from studies of crystals of diamond type structure are given.

J. KOCKUM, *Radiation Physics Department, University of Lund and* N. STARFELT,[1] *Department of Physics, University of Lund*

Measurement of photonuclear absorption cross sections

The total photonuclear cross sections for carbon, aluminium, sulphur, and iron have been measured in the energy region of the giant resonance. A total absorption scintillation spectrometer was used to study the transmission of the bremsstrahlung spectrum from a 30 MeV synchrotron through long absorbers. The integrated total photonuclear cross section between 10 and 27 MeV as well as the width of the giant resonance was obtained. The measured widths are definitely larger for the deformed nuclei aluminium and iron than for the spherical carbon nucleus, whereas the width for sulphur has an intermediate value.

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[1] Now at Research Institute of National Defence, Stockholm.

K. KRISTIANSSON, O. MATHIESEN and B. WALDESKOG, *Department of Physics, University of Lund*

The charge spectrum of heavy primaries in cosmic radiation and the universal abundance of the elements

The relative abundance of different nuclei in the primary cosmic radiation has been studied with methods discussed by Mathiesen and Waldeskog.[1] Some results from the measurements on particles with $Z > 8$ will be mentioned. Magnesium is the most abundant element in this part of the spectrum. Nuclei with even charge (Ne, Mg, Si, S) are much more abundant than nuclei with odd charge (F, Na, Al, P). The ratio between the number of particles with even and odd charges is larger than 5. Particles with nuclear charge as high as $Z = 26$ have been identified. The number of Cr and Ti nuclei in the iron group seems to be considerable.

A comparison between the spectrum of the cosmic radiation and the mean composition of the universe shows appreciable differences. If the number of particles in the iron group is compared with the number of particles in the group $10 \leqslant Z \leqslant 16$ the ratio will be much larger in the cosmic radiation than in the universe. The composition of the groups is also different from the mean composition.

B. LAMM, *Nobel Institute of Chemistry, Stockholm*

Assaying of beta-active isotopes by means of liquid scintillation counting

Liquid scintillation counting as a means of assaying beta-active isotopes has been proved to be a most promising analytical method, which complements other current methods of beta-activity measurement. In the report, some of its advantages and disadvantages as compared to earlier methods will be discussed. Some results concerning "quenching" effects provoked by different compounds on determining the tritium (H^3) beta radiation of max. 18 keV, will be presented. A comparison of commercially available equipment will also be made.

K. E. LARSSON, *AB Atomenergi, Stockholm*

Lattice dynamics in aluminium studied by slow neutrons

During the latest five years theories and new experimental methods have been created to tackle the old problem of the dynamics of solids and in part liquids. Using the slow neutron flux from the reactor R1 in Stockholm a method has been developed to study in detail the physics of lattice dynamics by way of cold neutron scattering. This new technique has been applied to the study of the phonons in a single aluminium crystal. The results involve information on such topics as dispersion, mean life time and mean free path of phonons in a temperature range from 293°K to 942°K, i.e. up to and above the melting point of the crystal. The results are compared to existing theories.

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[1] MATHIESEN and WALDESKOG, this conference.

B. E. LAURENT, *Institute of Theoretical Physics, University of Stockholm*

Conservation identities in connection with the generally covariant Dirac equation

Conservation identities are obtained from the action $\int \phi_{\mu\nu} s^{\mu\nu} d^4x$ proposed by Klein.[1] This is done using a variational procedure similar to the one used by Møller.[2]

In the action above

$$\phi_{\mu\nu} = \Gamma_{\nu,\mu} - \Gamma_{\mu,\nu} - [\Gamma_{\mu}, \Gamma_{\nu}]$$

and

$$s^{\mu\nu} = \tfrac{1}{2}[\gamma^{\mu}, \gamma^{\nu}]$$

where the matrices γ^{μ} and Γ_{μ} are the ones used in the generally covariant Dirac equation.

The result is a superpotential, $\mathrm{Tr}(\Gamma_{\alpha} s^{\beta\gamma})$, when the invariance of the action under coordinate transformations and a superpotential, $s^{\alpha\beta}$, when the invariance under S transformations is used.

B. LEHNERT, *Department of Electronics, Royal Institute of Technology, Stockholm*

On the confinement of charged particles in a magnetic field

A self-sustained thermonuclear fusion reaction requires a high degree of particle confinement. A ring-shaped solid conductor placed in the interior of the reaction volume produces a strong poloidal magnetic field which traps particles completely, at least at low gas densities. The leads which supply current to the conductor can be arranged in a way such as to prevent particle losses out of the confinement volume. Modifications and improvements of the magnetic field configuration by the addition of auxiliary coils are discussed.

Injection of ions into the confinement volume is discussed briefly as well as a number of other possible heating mechanisms. A short consideration of the stability problem is also given at the end of the present paper.

B. LEHNERT and F. C. HOH, *Department of Electronics, Royal Institute of Technology, Stockholm*

Experiments on diffusion in a plasma column in a longitudinal magnetic field

The paper forms an extension of earlier investigations (Proc. II. Int. Conf. on the Peaceful Uses of Atomic Energy, Geneva 1958, P/146) on diffusion processes in the positive column in a longitudinal magnetic field. The experimental results agree with the binary collision theory in a range of magnetic field strengths below a certain limit. Above this limit measurements of the longitudinal electric field as well as probe measurements indicate a rapid increase in the rate of escape of particles across the magnetic field. The transition depends upon the nature of the gas and its density. Variation of external circuit parameters does not influence the results. End effects of the magnetic coil are investigated and it is found that the results are sensitive to the length of the coil only when it is less than some fifty tube diameters.

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[1] O. KLEIN, To be published in Ark. f. Fysik.

[2] C. MØLLER, Dan. Mat. Fys. Medd. *31*, no. 14 (1959).

C. A. LERJEFORS and E. KARLSSON, *Institute of Physics, University of Uppsala*

Improvements in the experimental technique for measurements of magnetic moments of excited states

An investigation of optimum conditions for measurements of nuclear g-factors by angular correlation methods is presented. It is found that with the arrangement adjusted for maximum sensitivity it is possible to measure magnetic moments of excited states with life-times down to 10^{-10} seconds. The multichannel goniometer is very suitable for the method because of its inherent symmetry properties. It has now been provided with high resolution coincidence equipment and with an electromagnet of improved construction it will be possible to cover a large number of isotopes in the region 10^{-9}–10^{-10} sec. which are of great theoretical interest.

L. LINDBERG, *Department of Electronics, Royal Institute of Technology, Stockholm*

Experiments with a coaxial plasma gun

A condenser battery is discharged between two coaxial cylinders in hydrogen of low pressure. At a condenser voltage of 6 kV a peak current of 250 kA is obtained. A highly ionized plasma is formed, which moves in axial direction due to the electromagnetic forces of the discharge current. It leaves the gun and proceeds in a glass cylinder with a velocity of 60 km/s. At the opening of the gun the plasma collides with a static magnetic field, the field lines of which are stretched out into the glass cylinder. The plasma has a tendency to form self-contained magnetized rings. Kerr-cell cameras and magnetic loops and probes are used to study the plasma.

B. LINDELL, *Institute of Radiophysics, Stockholm*

Low-level radioactivity measurements with a body counter

Radioactive contamination of the human body, food and water can be measured by scintillation counters down to very low levels, if large crystals are used in a set-up that is shielded against radiation from the environment. A complete shield weighs about 50 ton, but many measurements can be performed almost as satisfactorily in a compromise arrangement used at the Institute of Radiophysics, Stockholm, utilizing only 5.5 ton of iron and one ton of lead. The first measurements of the background radiation and its spectral distribution are described. The total background counting rate within the region 50–1700 keV is about 460 cpm. The background increases with about 100 cpm by scattering from the body in the case of measurements on man; this contribution is, however, of fairly low photon energy and does not disturb most measurements significantly. All measurements were made with a 4″ × ⌀ 5″ NaI crystal (Harshaw), EMI photomultiplier 6099 F and a Hutchinson-Scarrot pulse-height analyser of the type modified by FOA.

I. LINDGREN, C. M. JOHANSSON-OLSMATS and S. AXENSTEN, *Institute of Physics, University of Uppsala*

Atomic beam investigations of radioactive isotopes in the lead region

The nuclear spins, magnetic dipole and electric quadrupole moments of some neutron deficient bismuth ($Bi^{199-206}$) and thallium ($Tl^{198, 201}$) isotopes have been measured by the atomic beam magnetic resonance "flop in" method, using six-pole focusing and radioactive detection.

As several isotopes investigated have a half-life of only about half an hour, it has been necessary to reduce the time required to get an atomic beam. Therefore a new oven arrangement has been constructed, which makes it possible to push the oven into the oven chamber in a few minutes without disturbing the vacuum. The identification of the radioactive isotopes was performed by their half-lives, but in one case mass separated samples were also used (Tl^{198}).

The magnetic moments of the bismuth nuclei have been obtained from the magnetic hfs by comparison with Bi^{209}. To obtain the electric quadrupole moments one has to know the value of $\langle r^{-3} \rangle$ for the valence electrons. This can be determined from Bi^{209} by means of either the magnetic hfs or the electron spin-orbit coupling, which methods are in agreement within the limits of error.

The magnetic moments obtained are in agreement with the "modified" single-particle model, while the quadrupole moments increase rapidly from the single-particle values with the number of neutron holes. All spin values are consistent with the shell model, but some irregularities are observed for the most neutron-deficient bismuth isotopes.

E. R. Lindgren, *Department of Mechanics, Royal Institute of Technology, Stockholm*

Some features of the structure of turbulent shear

Continued experiments on tube flow by means of the stream bi-refringence method using White Hector bentonite sols have revealed that transition between laminar and turbulent flow in tubes takes place as the formation of turbulent spots at the bounding walls in the same manner as observed by other authors on flow over flat plates. The turbulent spots may fade away or grow into turbulent slugs in the flow during their downstream transport along the tube.

It is confirmed that the self-preserving turbulent slug should be looked upon as being composed of one or several selfpreserving turbulent spots along the tube walls with an appurtenant flow core of eddies with decay which continuously diffuse from the turbulence generating spot into more central parts of the flow.

Since the velocity is highest in the middle of the flow the decaying eddies reach farthest ahead of their generating body in the tube centre before they fade away. This accounts for the always pointed front and the somewhat hollow rear of the turbulent slugs.

In case the Reynolds number is high enough the decaying eddies emanating from an already existing turbulent spot of a slug may cause breakdown of the flow ahead of the spot, with a subsequent formation of a new spot ahead of the old one. In this way previously reported observations on the splitting of turbulent slugs at lower Reynolds numbers and the more or less continuous elongation of turbulent streaks for higher Reynolds numbers are accounted for.

It is found, not only that the turbulent streaks are inhomogeneously maintained by a number of selfpreserving discrete turbulent spots but that this is so also in the case of fully developed turbulent tube flow, at least within a Reynolds number region of up to about 5000–7000 within a distance of about 200 tube diameters from the inlet. These findings are not consistent with prevailing ideas on the structure of turbulent shear.

E. LINDHOLM and H. VON KOCH, *Department of Physics, Royal Institute of Technology, Stockholm*

Dissociation of molecular ions formed during charge exchange

In a double mass-spectrometer the mass spectra of C_2H_5OH have been obtained by means of bombardment by positive ions. The primary process is charge exchange, and then the molecular ion dissociates. The dissociation process is dependent on the recombination energy of the incident ion. The velocity of the incident ion is low (20 eV). It has been possible to determine the mass spectrum as a function of the energy absorbed by the molecule during the process of ionization. This is of interest as integration gives the mass spectrum obtained in electron impact. Further it is of interest as it gives experimental information about the dissociation processes in a large molecule. These have been treated in the absolute rate theory by Eyring *et al.*, but the bad agreement with our experimental results makes it probable that the decomposition of the molecule-ions is determined by the location of a particular bond from which the electron is removed.

J. LINDSKOG, E. BASHANDY and T. R. GERHOLM, *Institute of Physics, University of Uppsala*

$0{,}7 \times 10^{-10}$ sec. half-life of the 330 keV excited state in Tl^{201}

The lifetime of the 330 keV first excited state in Tl^{201} has been measured. The 360 keV transition feeding this level was resolved from the de-exciting 330 keV transitions by means of the electron-electron coincidence spectrometer. Delayed coincidence technique was used to measure the lifetime. A resolving time of 2.1 mμs was obtained in the spectrometer using plastic scintillators and RCA 6810A photomultipliers with a coincidence circuit of the Bell type. The difference in transition energies gives rise to an instrumental time delay. To correct for this delay a new method was used. Coincidences were taken between the K 360 and K 330 as well as between the K 360 and L 330. In these two measurements the instrumental time delays are equal but have opposite signs. The half-life of the 330 keV level was then found to be $(0.7 \pm 0.2) \times 10^{-10}$ sec.

With high resolution double focusing spectrometer the $K/(L_{\mathrm{I}}+L_{\mathrm{II}})$ ratio was measured to be 4.2 ± 0.2 and the $(L_{\mathrm{I}}+L_{\mathrm{II}})/L_{\mathrm{III}}$ ratio to be 6.5 ± 0.5. From these ratios and the theoretical conversion coefficients the E2/M1 mixing was determined to be $\delta^2 = 2.2 \pm 0.4$.

Finally, the partial transition rates were computed. T(E2) was found to be 60×10^8 sec.$^{-1}$, which corresponds to an enhancement factor of 17.4 when compared to the single particle shell model. The T(M1) is 28×10^8 corresponding to a retardation factor of 380.

These figures will be compared with results previously obtained at this institute on Tl^{203}.

A. R. E. LODDING, *Department of Physics, Chalmers University of Technology, Gothenburg*

Isotope electro-migration and self-transferrence in molten K and Rb

When direct current is passed through molten metals, an isotope enrichment process takes place. The light isotope migrates towards the anode. The mass effect (defined as the relative migration velocity difference of the isotopes, divided by their relative mass difference, taking the electron cloud as velocity reference system) is of the order $\mu \sim 10^{-5}$. The temperature dependence of this process was recently investigated in K and Rb. At lower temperatures, μ was found to increase with the temperature, in accordance with earlier results for other metals. However, above ca 270°C for K and 190°C for Rb, μ decreased again.

The existence of an optimal enrichment temperature can be predicted, if the isotope effect is treated as the consequence of self-transference (i.e. ionic conductivity), induced mainly by electron–ion friction. Experiments suggest that the activation energy for self-transference is considerably higher than that for self-diffusion.

K. G. Malmfors, *Nobel Institute of Physics, Stockholm*

Preliminary results with the trochoidal spectrometer

A brief description is given of the operation principle and actual design of a time-of-flight β-spectrometer with trochoidal orbits. The spectrometer has been tested with β- γ-coincidences. Preliminary results concerning the resolution are in agreement with what was expected, $\sim 1\,\%$. The transmission, however, has been found to be 2–4 times less than the calculated value, 8 %.

I. Marklund, *Institute of Physics, University of Uppsala*

Quadrupole vibrations in the rare earth region

The quadrupole vibrations of beta type of deformed nuclei have only been found in a few cases in the heavy element region. A search is started in order to find such levels also in the rare earth region. A 0^+ level of beta vibrational type at 685.0 keV is found in the deformed nucleus Sm^{152} by measuring conversion coefficients. Its corresponding 0^+ level of two-phonon type is observed in Gd^{152} at 615.3 keV. The strongly deformed nucleus Er^{166} has a 0^+ level at 1460.4 keV, now confirmed by angular correlation measurements. The 1087 keV level in Os^{188} and the 1267 keV level in the spherical nucleus Pt^{194} are also measured by angular correlation to have zero spin, indicating the same trend of the 0^+ levels as theoretically expected. When the beta and gamma vibrational bands are known the theoretical and experimental rotational vibrational coefficients can be compared, $B^{\text{theory}} = kB^{\text{exp}}$.

A k-value of 2–4 is found, indicating a weaker coupling than theoretically expected or a positive coupling term of the same order of magnitude as the rotational–vibrational term.

I. Marklund and G. Bäckström, *Institute of Physics, University of Uppsala*

Decay of As^{76}

The decay of As^{76} has been investigated with external conversion, gamma-gamma and beta-gamma coincidences. Some new weak transitions have been established and several earlier reported lines are found to be of double character. The gamma energies in keV are: 559.28, 657.36, 869.1, 1216.0, 1228.7, 1438.3, 1435.5, 1788.6, 2097.2, 2111.8. (no ≈ 2400), 2655.8. The resulting decay scheme gives excited levels in Se^{76} at 559.3, 1216.6, 1788.3, 2111.8 and 2655.8 keV.

O. MATHIESEN and B. WALDESKOG, *Department of Physics, University of Lund*

Determination of the charge spectrum of relativistic heavy primaries in cosmic radiation

As a well-separated charge spectrum seems to be a primary condition for the study of the cosmic radiation, a new method of measurement has been developed at the institute. The method is based on photometric mesaurements on tracks in emulsion plates exposed at high altitudes.

Up to now 150 tracks with charge $Z \geqslant 3$ have been measured. Practically full separation between consecutive charges up to $Z = 26$ has been obtained. No particle with $Z > 26$ has been registered.

Particles with odd Z are much more rare than particles with even Z. An exception seems to be boron $Z = 5$.

O. MATHIESEN, *Department of Physics, University of Lund*

A comparison between δ-ray counts and photometric measurements on relativistic heavy primaries in cosmic radiation

The new technique to determine the charges of heavy primaries in the cosmic radiation by photometric measurements gives a complete resolution between consecutive charges at least in the region $Z \leqslant 10$.[1] Such identification makes it possible for the first time to examine the applicability of δ-ray counting on a well defined material in the region mentioned. The investigation confirms that the δ-ray density varies linearly with Z^2. However, by counting 100 δ-rays, the standard deviations are $12.2 \pm 0.9\,\%$ in the mean, indicating that besides the pure statistical errors there are other sources of errors, which totally amount to $7.0 \pm 1.6\,\%$. Furthermore, the results are often subject to large fluctuations, which only can be ascribed to subjective factors in the counting. The charge-spectrum obtained corresponds in its main feature to earlier charge-spectra based on δ-ray counting.

L. MINNHAGEN, *Department of Physics, University of Lund*

High quantum levels in the spectrum of Ar II

The spectrum of Ar II has been investigated in the whole 13 000–2000 Å range as well as in the vacuum ultraviolet. The analysis has revealed a large number of nf and ng levels not previously known. The $(^3P)4f,5f$ $(^3P)5g,6g,7g$ and $(^1D)4f$ configurations are now complete, $(^3P)6f$ is nearly complete; some $(^3P)7f$, $(^3P)8g$ and $(^1D)5f$ levels have also been found and classified. The $(^3P)ng$ levels appear in close pairs indicating extreme pair-coupling; the same type of coupling is also approached for the nf levels. The selection rules for pure pair-coupling ($\Delta l = \pm 1$, $\Delta K = 0, \pm 1$, $\Delta J = 0, \pm 1$) are as a rule valid for the $(^3P)4f$–$(^3P)ng$ transitions, but there are a few exceptions. Thus the $(^3P)4f[3]_{3\frac{1}{2}}$–$(^3P)ng[5]_{4\frac{1}{2}}$ lines are nearly as strong as the $4f[3]_{3\frac{1}{2}}$–$ng[4]_{4\frac{1}{2}}$ lines, one reason being that the $ng[4]_{4\frac{1}{2}}$ and $ng[5]_{4\frac{1}{2}}$ levels are very close to each other.

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[1] MATHIESEN and WALDESKOG, this conference.

L. MINNHAGEN and B. PETERSSON, *Department of Physics, University of Lund*

On the excitation of spectra of ionized xenon

The spectra of XeII, III and IV have been investigated by means of an electrodeless high frequency discharge worked out in collaboration with Dr. L. Stigmark. The equipment consists of a pulsed oscillator with a driver connected to a power amplifier with two water-cooled triodes in a push-pull arrangement. The operating frequency is 18 Mc/s and the available pulse power, using a pulse duration of 80 μs, and a pulse repetition of 50 c/s, will be 400 kW fed out to the final discharge tube circuit. By changing the pulse power it is possible to recognize lines belonging to the different ionization stages.

P. MITLID, *Department of Electronics, Royal Institute of Technology, Stockholm*

Equipment for high current discharges

Ignitrons used as switches for discharging stored energies of the order of 5 kJ are described. The discharge apparatus and measuring equipment are started at adjustable intervals by a master triggering circuit.

C.-G. MONTELIUS, *Institute of Physics, University of Uppsala*

X-ray wavelength measurements of L-emission lines from the elements 24 Cr to 32 Ge

A concave grating spectrograph with grazing incidence is used for the measurements. The reference system consists of K-emission lines from elements 11 Na, 12 Mg and 13 Al (unresolved K_α doublet) in various orders covering 8 to 50 Å. Some of the weaker lines are measured for the first time. For experimental reasons 31 Ga is excluded from the investigation.

E. MÖLLER, *Department of Physics, University of Lund*

The van de Graaff generator in Lund

This generator, built under the direction of Prof. S. von Friesen, is a horizontal, pressure insulated machine. Tank dimensions: diameter 2 m, length 7 m. The inside of the tank is covered by polished stainless steel. The electrode material is aluminium. The diameter of the high voltage electrode is 1 m and of the intermediate shield (at 2/3 of the total voltage) 1.4 m. The mechanical structure is made from textolite tubes. The belt is rubberized cotton, velocity 20 m/s.—Acceleration tube: porcelain insulators, corrugated inside and outside. Electrode material stainless steel, inner diameter of the electrodes 90 mm. Total tube length 4.2 m.—Vacuum pump: mercury, speed 30 l/s.—Ion source: high frequency, of Los Alamos type. The ion source is controlled by a system, using light beams.—Gas in the tank: nitrogen and carbon dioxide, proportions 4:1. Max. pressure used 11 at.

The machine has been used from 0.27 to 2.6 MV with currents up to 50 μA. Maximum voltage at present 3 MV. This limit is set by discharges through the tube. The voltage is stabilized by use of a corona triod or by corrections on the charging current.

The beam can be taken out at 20 and 28 degrees to both sides. After 28 degrees deflection, it may be used for neutron production in a separate room, 7 m from the magnet. In this case the beam is kept together by magnetic quadrupole lenses.

H. NEUHAUS, *Department of Physics, University of Stockholm*

Neue Versuche mit dem Immersionsgitter

Das Hulthén-Immersionsgitter besteht aus einem Gitter, welches mittelst Immersionsöl ($\mu_i = 1.7$ bei 4300 Å) mit einem 30°/60°-Glasprisma zusammengekittet ist. Das totale Auflösungsvermögen des Immersionsgitters setzt sich aus dem Auflösungsvermögen a) des Gitters, welches durch das[1,2] Immersionsöl etwa μ_i-Mal vergrössert wird und b) des Prismas zusammen. Durch eine geeignete Spiegelanordnung kann das Licht zwei Mal durch das Immersionsgitter geführt und zerlegt werden, mit der Folge, dass das Auflösungsvermögen sich verdoppelt[3]. Die Verwendbarkeit des Verfahrens wird auf die Hg-Linien geprüft. Eine Dispersion von 15 mm/Å bei 5461 Å (Fokal-Länge 6 m) ist erreicht worden[4].

A. NILSSON, *Nobel Institute of Physics, Stockholm*

Angular distribution measurements on the reaction Li^7 (p, n) Be^7

The investigation was performed with the time-of-flight arrangement at the 80 cm cyclotron of the Nobel Institute. Time spectra were integrated photographically from an oscilloscope display. The energy of the protons was varied by inserting silver stoppers of different thickness just before the target. The main neutron group was studied at proton energies 3.53, 3.20, 3.01 and 2.72 MeV, the angles ranging from 0° to 150°. Because of the energy straggling in the stoppers, a complete distribution for the secondary group (leading to the 435 keV level in Be^7) could be obtained only at 3.53 MeV. The center-of-mass differential cross section of the main group could be expressed $a_0P_0 + a_1P_1 + a_2P_2$ (P being Legendre polynomials), where the coefficients a_i showed a small energy dependence that joined fairly well to previous results at smaller energies. The secondary group was isotropical in the center-of-mass system.

J. NILSSON, *Department of Theoretical Physics, Chalmers University of Technology, Gothenburg*

Polarization effects in threebody Kaon decay

The V-A theory for weak interactions developed by Sudarshan and Marshak and, independently, by Feynman and Gell-Mann has been remarkably successful in

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[1] HULTHÉN, E. und H. NEUHAUS, Ark. Fys. *8*, 343 (1954).

[2] NEUHAUS, H., Diss. 1959.

[3] HULTHÉN, E. und LIND, E., Ark. Fys. *2*, 253 (1950).

[4] BJÖRKLUND, O., Ark. Fys. *13*, 185 (1958).

clarifying the experimental data available from weak processes. In the search for possible new tests of this theory the threebody kaon decay (Ke_3 and $K\mu_3$) has been considered by different authors as the only process where the electron and the muon modes both actually have been observed. If the muon and the electron are considered identical particles except for the mass difference the transition matrix element will be of the same form for these two modes and it can be obtained by general invariance considerations.

Calculations of polarization effects in the final lepton states have been carried out and to a certain extent compared to available data. Due to the poor statistics, however, no definite conclusions can be drawn until further experimental investigations have narrowed the limits of error.

R. Nilsson, *AB Atomenergi, Stockholm*

Neutron spectrum measurements in iron

When neutrons penetrate an iron shield the neutron spectrum is considerably changed. This change has been measured by means of different kinds of foils in a stratified iron plug in the iron lid of the Swedish reactor R 1.

The measurements have shown that the thermal flux at first decreases with a relaxation length of (1.51 ± 0.02) cm. The relaxation length of the neutrons in the resonance region (0.1 eV $\lesssim E \lesssim 0.1$ MeV) is about 16 cm. The fast neutrons ($E \gtrsim 0.1$ MeV) are attenuated rather quickly due to inelastic scattering. The relaxation length, 6.3–8.7 cm, depends on the energy of the fast neutrons. Thus after some twenty or thirty centimeters the neutrons of intermediate energy predominate in the neutron flux, which is consistent with the fact that iron has several large antiresonances in the total neutron cross section curve in the interval 25–400 keV.

R. Nilsson, Ingrid Olsson, A. Berggren and K. Siegbahn, *Institute of Physics, University of Uppsala*

S^{35} and Be^7 contents in rain and snow

The contents of S^{35} and Be^7 have been measured in some rain and snow samples from Uppsala and Abisko. The average concentrations of S^{35} were 230 and 175 atoms cm^{-3}, and of Be^7 1500 and 3000 atoms $\cdot$ cm^{-3} respectively.

Calculations of the production rate of Be^7 have been made for different locations, where measurements of Be^7 activity have been carried out. The theoretical calculations agree at least qualitatively with the experimental data, and it would appear that the deposition rate is influenced by the varation of the tropopause height with latitude and season.

S. Nilsson, *Institute of Physics, University of Uppsala*

K^- capture on free and bound protons

When a negative K-meson is absorbed by free and bound protons a possible process is emission of a charged Σ-hyperon plus a charged π-meson. 62 events of this type in nuclear emulsions have been analysed. In case of absorption by bound protons the outgoing Σ and π define a production plane. The angular distribution of the π-meson from the decay of the Σ-hyperon with respect to the normal to this plane is given and its implications for the question of parity conservation in the Σ-decay is discussed. The lifetimes of the Σ-hyperons are given.

S. G. NILSSON and O. PRIOR, *Nordita, Copenhagen, and Institute of Theoretical Physics, University of Lund*

Pair correllations and the rotational moments of inertia of deformed nuclei

Within the picture of completely independent single particles moving in a rotating deformed potential it is a wellknown result that the moment of inertia comes out to be equal to the rigid value. This situation is often compared with the case of independent gas molecules moving in a rotating nonspherical container. The experimentally found deviation from the rigid value of the moment of inertia, $I^{\text{exp}} \sim (0.3\text{–}0.5)\, I^{\text{rigid}}$, for even-even nuclei is usually attributed to correlations between the single particles. Such a correlation that acts between pairs of particles has been introduced in nuclear theory by Bohr, Mottelson, Belyaev and others by a method that is analogous to that developed in the Bardeen theory of superconductivity.

An application of the methods to deformed even-even nuclei in the rare earth region gives values of the moment of inertia within $\sim 10\,\%$ of the empirical values if the pair correlation strength is chosen so as to reproduce the observed energy gap in adjacent even-even nuclei.

T. NILSSON, *AB Atomenergi, Stockholm*

Buckling measurements on reactor models

The pulsed neutron source method has been used to measure the geometric buckling of reactor models, consisting of a cylinder with either a hemisphere or a spherical segment at one or both ends of the cylinder. The models were made of polythene. The buckling of these geometries has also been calculated on an electronic computer and good agreement between measurements and calculations was obtained.

The change in buckling when suspending a cadmium rod in different ways through a cylinder containing light water has been measured as well. Good agreement with the theory was found for central rods but for diagonal rods it is difficult to make any comparisons, as no good theory exists in that case. Anyway, the results seem to be reasonable.

B. NORDFORS, *Institute of Physics, University of Uppsala*

Optimum absorber thickness for X-ray absorption measurements

When determining an X-ray absorption coefficient using a counter tube the statistical error in μ depends not only on the number of counts but is also a function of the absorber thickness d and of the time ratio t/t_0, where t is the time spent on measuring the transmitted intensity and t_0 the corresponding time for the direct intensity. If the background radiation is negligible the following values of d and t/t_0 represent the minimum statistical error in μ:

$$d=\frac{2.56}{\mu};\ \frac{t}{t_0}=3.59.$$

If the background cannot be neglected the optimum values will further depend on its relative intensity and its average absorption in the foil. In this instance the mathematical treatment is somewhat more complicated than in the simple case where no background is present and leads to a system of two transcendent equations, which can, however, be solved graphically without too much effort.

The general trend is that foils of greater thickness than given by the expression above are required if the background is absorbed more than the main radiation, while the opposite case calls for thinner foils. The time ratio varies but slightly with background radiation and always towards lower values.

Finally it may be mentioned that the minimum of the curve giving the relative error in μ as a function of d is very flat and broad, thus making the optimum value of absorber thickness rather non-critical.

C. NORDLING and S. HAGSTRÖM, *Institute of Physics, University of Uppsala*

Atomic energy levels determined by the photoelectron method

The photoelectron method of determining binding energies of electrons in inner shells has been applied to a study of K level energies in some fourth period elements,[1] L level energies in the elements rhodium through tellurium[1] and L, M and N energies in uranium.[2] An accuracy better than one electron volt is achieved in the measurements. The K energy of arsenic has recently been measured and found to be 11866.7 ± 0.8 eV. For the elements in the fourth and fifth periods a good agreement with X-ray absorption measurements is generally obtained, although certain discrepancies seem to exist between the results obtained by the two methods. No precise wavelength determinations have been made of the M and N absorption edges in the element uranium, and a comparison with X-ray data is instead performed by making use of the wavelengths of emission lines. The L_{I}, L_{II} and L_{III} level energies are calculated by adding to the M and N binding energies, determined by the photo electron method, X-ray transition energies of the L spectrum. A discrepancy of 2.6 eV is observed between the calculated L_{III} energy and that obtained from a direct measurement with the photo electron method.

E. ODEBLAD, *Nobel Institute of Physics, Stockholm*

Proton magnetic resonance studies on the physical state of living cells

The properties will be described of acetic acid–water mixtures for the measurement of the position of proton resonance signals with an accuracy of about ± 0.02 ppm. This calibration mixture has been used to study the position of the resonance signal of the water phase of biological specimens. This water phase is usually localized between -0.2 and $+0.1$ ppm (pure water $=0$) in different objects. Several mucoids in the body show approximately $T_1=1$ sec. and $T_2=0.1$ sec. The viscosity data indicate that the relaxation times should be of the order of 0.001 sec. A molecular arrangement, which explains this difference has been proposed. After exchange of living cells with D_2O one obtains proton resonance signals which are too narrow to be explained by a rigid lattice of the proteins in the cells. The data therefore indicate that the so-named solid substance in a cell executes large rotational, vibrational, or translational movements.

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[1] Arkiv för Fysik *15*, 397 (1959).
[2] Arkiv för Fysik *15*, 431 (1959).

INGRID OLSSON and HL. DE VRIES, *Institute of Physics, University of Uppsala and Natuurkundig Laboratorium, Groningen*

A proportional counter for low level counting with high efficiency

Two small identical counters have been built in the C14 dating laboratories in Uppsala and Groningen from essentially the same material. The counting space is lined with quartz covered with a conducting layer; it is enclosed in a copper cylinder at ground potential. The background for the counter used in Uppsala is 0.9 cpm. The total volume is 0.55 l with an efficient volume of 0.46 l.

B. I. PERSSON and S. A. E. JOHANSSON, *Department of Physics, Universtity of Lund*

Internal bremsstrahlung from P^{32}

The spectrum of internal bremsstrahlung from P^{32} has been measured in a coincidence experiment. The β-particles are detected by an anthracene scintillation spectrometer and the bremsstrahlung spectrum measured by a sodium iodide scintillation spectrometer. Pulses in a certain energy range are selected in the anthracene spectrometer by a single channel analyzer. They are used to gate the 100 channel analyzer which records the bremsstrahlung spectrum. The angle of emission between the β-particles and the bremsstrahlung is defined by the orientation of the spectrometers. The experiment has been performed for a number of different angles. The experimental results are compared with the theory of Knipp and Uhlenbeck and of Bloch. The agreement is very good.

L. PERSSON and H. RYDE, *Nobel Institute of Physics, Stockholm*

An efficiency calibrated $3'' \times 3''$ NaI (Tl) scintillation spectrometer

A $3'' \times 3''$ NaI(Tl)-crystal scintillation spectrometer has been built and efficiency calibrated for gamma-ray intensity measurements. The spectrometer consists of an ordinary Hilger $3'' \times 3''$ NaI(Tl)-crystal optically coupled to a $3''$ Du Mont 6363 photomultiplier, a stabilized high tension supply, a White cathode follower and a Hutchinson-Scarrott pulse-height analyzer. An iron shield has been built, which decreases the total background below 1.5 MeV with a factor of about 7. The spectrometer works with a fixed geometry, and as the source is placed outside a hole in the shield, a certain collimation of the radiation is achieved.

The photopeak efficiency has been chosen as a measure of the efficiency. This has been determined according to Åström *et al.*[1] The efficiency calibration was performed with the radioactive isotopes Hg^{203}, Au^{198}, Cs^{137}, Na^{22} and Na^{24}. In these cases the conversion coefficients and gamma-ray intensities are relatively well known. The X-ray photopeaks have been corrected for iodine X-ray escape according to Axel.[2] This correction has been checked for the Tl^{203} X-ray photopeak.

The spectrometer will be used for gamma-ray spectrometry above 500 keV, where its higher efficiency compared with a smaller crystal, is very useful. Below 500 keV the scattering from the iron shield is rather troublesome. In this interval a smaller crystal with a minimum of surrounding material is used.

B. G. PETTERSSON, J. HAMILTON[3] and J. HOLLANDER,[4] *Institute of Physics, University of Uppsala*

Beta-gamma directional correlations in first forbidden transitions

Recently it was pointed out[5] that in cases where deviations from the "ξ-approximation" in first forbidden non-unique transitions are observed in the shape factor, additional information can be gained by measuring other observables such as beta-gamma correlations. When such measurements are performed relative magnitudes of different nuclear matrix-elements can be determined. This fact makes it possible to consider the connection of the beta-decay process with nuclear models.

Beta-gamma directional correlation measurements have been carried out with a magnetic spectrometer utilized for the beta-particle energy analysis. Anisotropic correlations have been found in $Ag^{111}(A_{\max}=2.5\,\%)$, $Pa^{233}(A_{\max}=5\,\%)$ and $Rb^{86}(A_{\max}=25\,\%)$. The measured energy dependence of these correlations is discussed in terms of the ξ-expansion.

V. PETTERSSON, *Department of Physics, University of Stockholm*

The TiO-band 11032 Å

Two singlet band systems have so far been identified in the spectrum of the TiO-molecule, both analyzed by Phillips. An infrared band system at 8860 Å corresponds to a $^1\pi-^1\Delta$ transition, and a yellow one at 5598 Å to a $^1\phi-^1\Delta$. They have the lower state in common.

A rotational analysis of the infrared TiO-band 11032.2 Å has now been carried out. It is the O–O band of a $^1\pi-^1\Sigma$ transition, which has the upper state in common with the $^1\pi-^1\Delta$ band at 8860 Å.

A. RAMGARD, *Division of Mathematical Physics, Royal Institute of Technology, Stockholm*

Conditions for equilibrium and stability of a plasma ring in an external magnetic field

The equilibrium of a bounded plasma configuration in the form of a thin axially symmetric ring with helical surface currents in an external magnetic field is studied and the stability is discussed. The behaviour at large is treated approximately by using Lagrange's equations.

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[1] ÅSTRÖM, WAPSTRA, THULIN and BERGSTRÖM, Arkiv för Fysik. *7*, 247 (1953)

[2] AXEL, Rev. Sci. Instr. *25*, 391 (1954).

[3] National Science Foundation Fellow on leave from Vanderbilt University.

[4] Guggenheim Fellow on leave from University of California.

[5] T. KOTANI and M. ROSS, Phys. Rev. Letters *1*, 140 (1958).

B. Ronne, G. Ekspong and Å. Frisk, *Institute of Physics, University of Uppsala*

Annihilation of antiprotons

A stack of nuclear emulsions has been exposed for antiprotons at the Bevatron, Berkeley. The analysis of 346 antiproton capture stars, of which 179 occurred in flight, will be presented. We have examined the division of the available energy between pimesons, strange particles and nucleons. The average values of the observed charged pion multiplicities are 2.36 ± 0.11 and 2.22 ± 0.10 at annihilations at rest and in flight respectively. We have established the occurrence of four K-mesons and one Λ^0-hyperon bound in a hyperfragment.

J. Rosén, *AB Atomenergi, Stockholm*

The absorption of neutrons in Doppler broadened U^{238}-resonances

In slowing down from fission to thermal energy the neutrons in a reactor have to pass an energy region in which U^{238} has strong absorption lines. An effective cross section for a uranium lump of given geometry has been deduced by Wigner. A theoretical investigation has been undertaken at AB Atomenergi to calculate for some cases of practical interest how the cross section is affected by an increase of the uranium temperature.

A. E. Sandström, *Institute of Physics, University of Uppsala*

Registrations of cosmic ray intensity variations

Registrations of cosmic ray intensity variations have been made in Sweden during a comparatively long time. In anticipation of the IGY, new equipment was constructed and erected in Uppsala (59°51′ N, 17°55′ E) and Kiruna (67°50′ N, 20°26′ E) and also at Murchison bay, Svalbard (80°03′ N, 18°15′ E). In Uppsala and Murchison bay the instrumentation is identical consisting of a neutron pile monitor, a so called international standard cubical meson telescope, and directional meson telescopes for zenith angles 30° to the east and west. In the equipment for the Kiruna station the monitor had to be omitted for economical reasons. The directional telescopes in Kiruna are recording the incoming mesons around the zenith angles 30° to the north and to the south. The old recording station in Stockholm is not equipped with international standard instruments. The meson telescopes measure in three directions, zenith, 45° to the north, and 45° to the south. Counting rates, dates of starting, etc. will be shown in tables on slides.

An elaborate scheme for testing and controlling has been worked out. The data treatment is concentrated to Uppsala. Calculating machines, punch cards, and electronic computers are being used on an extensive scale. Some results will be demonstrated by means of slides.

R. Sandström, *Institute of Physics, University of Uppsala*

Bremsstrahlung-isochromats

The structure near the short-wavelength limit of the continuous X-ray spectrum has been studied by means of the isochromat method. A concave crystal spectrometer with a Geiger counter was employed. The ripple of the accelerating voltage across the X-ray tube (about 3700 volts) was less than 0.1 volt. The spectrometer lets through a spectral band approx. 3 volts wide.

Up to now only W and Mo have been investigated with this apparatus, the anticathode being held at about 1200°C in order to avoid contamination of the target. It was found that the peaks of the isochromats correspond closely to the peaks of the characteristic energy loss spectrum. The first peak at about 4.5 volts from the limit is made to correspond to the elastic peak of the energy loss spectrum. The peaks are pronounced, especially the first one, and fully reproducible.

Z. Sawa, *Nobel Institute of Physics, Stockholm*

Proton angular distributions from the D + d reaction for deuteron energies 0.5–0.9 Mev

A thin foil target, enriched on deuterium, was exposed to a deuteron beam accelerated with a Cockroft-Walton cascade generator. The protons from the reaction were analyzed by the double-focusing heavy particle spectrometer and registered in nuclear emulsions. The asymmetry of proton angular distributions in the reaction plane and C. M.-system can be expressed in the form:

$$\frac{d\sigma(\theta)}{d\Omega}=\frac{d\sigma(90^\circ)}{d\Omega}(1+A\cos^2\theta+B\cos^4\theta).$$

A and B are energy-dependent asymmetry coefficients as follows:

E_d in Mev	0.5	0.6	0.7	0.8	0.9
A	+0.56	0.50	0.34	0.29	0.01
B	+0.89	1.14	1.38	1.60	1.95

Z. Sawa, *Nobel Institute of Physics, Stockholm*

Polarization measurement of protons from the C^{12} (dp) reaction

In order to measure the polarization of proton-groups from stripping reactions a polarimeter-chamber was built. This chamber allows solid foils or gases to be used as the polarization analyzer. The polarization of protons from $C^{12}(dp)C^{13}$ was measured with carbon as polarimeter and an energy of the deuteron beam of 0.8 MeV. Preliminary evaluation of the experiment shows that P is $\sim -30\,\%$ in $K \times K_p$ direction).

O. Schelin, *Research Institute of National Defence, Stockholm*

Theoretical and experimental determination of the shielding against fallout-radiation

The degree of protection against the γ-radiation from a nuclear explosion afforded by residential structures, shelters etc. is being investigated. As the fundamental absorption- and scattering processes are well known, the difficulties are of a practical kind. In U.S.A. extensive calculations with data-machines of the transport of radiation have been carried out but are applicable only to simplified geometries of absorbing material as infinite homogenous medium, plane-parallel slabs etc. In handling a specific *object*, e.g. a normal house, far-reaching approximations must first be applied regarding form and wall-structures, whereafter the results of different types of theoretical calculations can be applied for the absorption in air and walls, the back-scattering from partitions and floors etc. In order to check and supplement the calculated values experimental determinations of attenuation factors are also made. The fallout on the ground and roof is then simulated with Co^{60}- and Cs^{137}-sources which are successively placed in a number of positions around the building. The dose rates inside are measured with ionization chambers. Numerical integration gives the dose rate relative to a uniform deposit of radioactivity. The strenghts of the sources make remote control necessary.

P. O. SCHÖRLING and P. OHLIN, *Institute of Physics, University of Uppsala*

X-ray flash spectra

K-spectra of Fe, Ni and Cu from an X-ray flash tube with low inductance have been recorded photographically and compared with spectra from an ordinary X-ray tube. In the flash spectrum the satellites Fe $K\beta_1$, Ni $K\beta_1$ and Cu $K\beta_1$ were definitely stronger, the line Fe $K\beta_1$ was broadened on the high energy side and the lines Fe $K\alpha_1$, Ni $K\alpha_1$ and Cu $K\alpha_1$ were broadened on the low energy side.

The intensity of an X-ray flash has been studied for some different electrode systems. A discharge circuit with very low inductance was used. The intensity was shown to depend strongly on the relative positions of the electrodes of the flash tube.

L. E. SELIN, *Physics Department, University of Stockholm*

Absorption spectrum of iodine bromide

IBr has three systems in the visible and the red part of the spectrum: one system between 5400–6000 Å with partially diffuse bands, one weaker system between 6100–6700 Å and one intense system above 6800 Å. Because of the equally abundant isotopes Br^{79} and Br^{81} and to the small differences between the B-values, the band-structures are very dense and complicated. However, the rotational analysis has been made possible by using an immersion grating with a dispersion of 5–7 mm/Å. Hitherto only the red system has been analyzed. This system is classified as a $^1\Sigma^+ \leftarrow {}^3\pi_1$ transition.

The vibrational and the rotational constants as well as the heat of dissociation are determined. An analysis of the two remaining systems is commenced at this institute.

J. SISEFSKY, *Research Institute of National Defence, Stockholm*

Autoradiographical examination of small radioactive particles

Autoradiographical methods have been worked out for the examination of radioactive particles in air-borne dust. The particles are collected on air-filters, which are autoradiographed. The particles give circular dense spots with diffuse edges. From the spot-sizes activities can be measured which are too small to be measured in other ways.

An autoradiographical method can also be used to identify the active particles under microscope and distinguish them from the much greater number of inactive dust particles on the filter paper. In this case the dust is cast into transparent celluloid films on glass plates. The plate is coated with nuclear emulsion in gel-form, which is reversally developed in situ with a special method, making the active particles indicated by clear spots against a brown transparent background. In the centres of the clear spots active particles down to 0.2 μ can be seen with a microscope.

B. SJÖGREN, *Nobel Institute of Physics, Stockholm*

Cyclotron instrumentation with high energy resolution for studies of nuclear reactions

At the small cyclotron of the Nobel Institute an instrumentation for high energy resolution studies of nuclear reactions has been built up. The beam from the cyclotron, being 7 MeV deuterons or 3.5 MeV protons, is directed and focused in a suitable manner by two small sector magnets and a pair of quadrupole magnets. The latter are newly constructed. They hang from the ceiling fixed at a frame in such a way that they can be moved freely several meters alsong the beam. The yoke consists of four iron plates and the magnets thus have a square section. After the quadrupole magnets the beam enters a 90° double-focusing magnetic analyzer which has a mean radius of 80 cm. The analyzer is mounted on a support so that it can be turned around the incoming beam without displacing the adjustments or breaking the vacuum. Thus it can easily bend the beam to equipment on one side of it or the other. It is also possible to take the beam out through a hole to an apparatus behind the magnet when its current is switched off. On one side the heavy particle spectrometer of the institute is set up. The analyzer has a rather large mean radius as its median plane is normal to that of the spectrometer. This means that the "radial direction" of the analyzer, determining the energy spread on the target, corresponds to the "axial direction" of the spectrometer. For a certain energy resolution the target spot size is thus given by the radius of the analyzer. To the spectrometer the following accessories have been constructed: a target chamber, a camera for nuclear emulsion plates with automatic operation, a robot device for change of the spectrometer direction and an ionisation chamber intended to be used as a monitor. The ionisation chamber is described in a separate report.[1] A precision current integrator has also been built. Some work has been started to get an electronical multichannel position detector to be used instead of photographic plates behind the spectrometer. A special type of proportional counter has been studied.[2] An arrangement with scintillation crystals having some advantages will also be tried. As it is often most desirable to vary the energy of the bombarding particles an absorption gas chamber to be put into the beam has been investigated. It will be placed before the quadrupole magnets. By varying the gas pressure in the chamber the particle energy should be variable within certain limits.

B. SJÖGREN and Z. SAWA, *Nobel Institute of Physics, Stockholm*

Investigation of N^{14} (d,p) N^{15}

By using the double-focusing heavy particle spectrograph of the Nobel Institute in combination with the Cockroft-Walton accelerator angular distributions of the proton groups, corresponding to the first two excited states of N^{15}, at 5.276 and 5.305 MeV respectively, were previously measured at $E_d=0.800$ MeV.[1] These measurements have now been extended to $E_d=0.500$, 0.600 and 0.700 MeV and the excitation functions for the energy region $E_d=0.500$–0.800 MeV have also been determined for one angle. The measuring technique was the same as in.[1] It is found that the angular distributions of the two proton groups are quite different. For the 5.276 MeV group the distribution varies little with deuteron energy, but for the 5.305 MeV group on the other hand a strong change takes place between 0.600 and 0.700 MeV. The excitation function of the latter group also has an irregularity at about 0.65 MeV, while it is smooth for the former. This seems to indicate that a compound nucleus formation is dominating in the latter case and that there is a level in O^{16} at about 21.31 MeV. However, a disintegration of this state by proton emission to the 5.276 MeV state of N^{15} is obviously suppressed or not allowed. The results for the 5.276 MeV group seem to indicate that stripping with $l_n=2$ is of importance also at these low energies. This would be in agreement with the result of a measurement at $E_d=7$ MeV.[2]

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[1] G. HAHN, Report at this conference.

[2] S. HJORT, Diploma work at the Royal Institute of Technology (1959).

An investigation of the $N^{14}(d,p)N^{15}$ ground state group is now being made. A scintillation spectrometer with a thin CsJ(Tl) crystal is used.

T. STAFLIN, *Institute of Optical Research, Royal Institute of Technology, Stockholm*

Photoinduced infra-red absorption in germanium and silicon

The optical absorption in semiconductors can conveniently be divided into four types.

1. Fundamental absorption, associated with transitions of electrons across the energy gap.
2. Absorption of free carriers.
3. Absorption associated with transitions to and from energy levels due to impurities or defects.
4. Absorption due to excitation of lattice vibrations.

By excitation with light, with photon energy larger than the band-gap, a free carrier increase was obtained, and the attached infrared absorption was measured.

The diffusion length of the free carriers has been obtained by means of measurement of the absorption increase at different distances from an illuminated crystal surface. The diffusion length for holes in an intrinsic germanium crystal was found to be 0.14 cm.

By the application of a method with chopped exciting light the absorption increase could be measured directly. In germanium the spectral distribution showed the known three maxima, attributed to the transitions between the three valence bands. In silicon an absorption which is proportional to $\lambda^{1.6}$ has been observed at room temperature in the wavelength interval 3–30 μ. This is in approximative accordance with the Drude–Fröhlich theory.

R. STEDMAN, *AB Atomenergi, Stockholm*

Measurements with a crystal spectrometer on one-phonon scattering of neutrons

The interaction of slow neutrons with single vibrational quanta in a crystal is utilized to determine the relation between frequency and wave vector for these quanta in particular directions. Crystal spectrometers are used to provide monoenergetic incident neutrons and to determine the energy of neutrons scattered in a certain direction. An innovation in the method of measurement largely eliminates the detrimental effect which coarse collimation otherwise has on resolving power. Measurements are as yet in a preliminary stage.

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[1] B. SJÖGREN and K. AHNLUND, Ark. f. Fys. *12*, 547 (1957).

[2] SHARP, R. D. and SPERDUTO, A., MIT Progress Report (May 1955).

L. G. STRÖMBERG, I. ASPLUND, and T. WIEDLING, *Department of Physics, University of Stockholm*

Mixing ratios of $2+-2+$ transitions in even-even nuclei in the mass region $A=122$–128

To get an idea of the effect on the $E2/M_1$ ratio of $2+-2+$ transitions when a neutron or proton pair is added to the nucleus, angular correlation measurements have been carried out on four $2+-2+-0+$ gamma cascades in the mass region $A=122$–128. The following nuclei have been studied: Te^{122}, Te^{126}, Xe^{126}, and Xe^{126}. In all these nuclei the $2+-2+$ transitions are of almost pure E2 character with a small admisture of M1. The δ-values have been determined to be $+3.7$, $+8.8$, $+9.9$, and -6.4, respectively. Unfortunately the decay scheme of Te^{124} is too complicated to be accurately investigated by angular correlation methods.

Z. SUJKOWSKI and H. RYDE, *Nobel Institute of Physics, Stockholm*

Measurements of the relative instensities of γ-rays of La^{140} and Ta^{182} by the method of external conversion

Relative intensities of fifteen γ-transitions in La^{140} and sixteen γ-transitions in Ta^{182} have been measured in a double focusing β-ray spectrometer by the method of external conversion. Scintillation and proportional counters have been used as detectors. Uranium converters of 0.85 and 2.16 mg/cm^2 thickness have been applied.

MARIANNE SUNDBOM, *Research Institute of National Defence, Stockholm*

On a numerical method for describing a fluid flow characterized by an internal discontinuity

We consider a spherical shell of a medium, which is assumed to behave like a compressible non-viscous fluid.

The problem considered is the description of the motion and the compression of the fluid, when a spherical shock, which has been formed at the inner radius of the shell, moves through the medium. The differential equations, which govern the motion, are solved numerically. The shock front is treated as a strict discontinuity.

T. SUNDSTRÖM and S. SVENNERSTEDT, *Institute of Physics, University of Uppsala*

An experimental study of the linear pinch stability

In a heavy current discharge the pinch is generally destroyed within a short time, unless some stabilizing means are tried. Among the different modes of gross instabilities the kink type is the most difficult one to suppress. Theories presented by different authors predict, however, that, if some ideal conditions are fulfilled, it is possible to inhibit even this mode by the combined action of an axial magnetic field and a conducting shell around the tube.

In the present work discharges have been made in a straight tube at a voltage $V = 15$–25 kV. The discharge current was 300–500 kA, and the frequency $\nu = 85$ kc/sec. The maximum axial magnetic field strength available was 1900 gauss. A ϕ_z-loop and two diametrically opposite B_θ-coils were used to detect the kink instabilities.

The present investigation revealed that in case of zero magnetic field the pinch was destroyed by kink instabilities usually at the time of the third contraction. In moderate magnetic fields stability was preserved until soon after current maximum. When a sufficiently high magnetic field has been applied, however, it has become impossible to detect kink instabilities. Thus discharges with currents up to 400 kA were stabilized by a magnetic field of 1900 gauss. Furthermore, interest has been paid to the electro-mechanical oscillation which is performed by the current sheath before the compression equilibrium is finally reached. The frequency of this oscillation has proved to depend on the initial gas density in the theoretically predicted manner.

J.-E. THUN, *Institute of Physics, Uppsala*

Wavelength shifts of the Cu $K\alpha$ doublet between metal and oxide

It has been known for a long time that the chemical composition of the anticathode influences the wavelength of the characteristic lines emitted from it. This is due to shifts of the energy levels of the atom. Various measurements have been carried out to show this effect by measuring the characteristic spectra of different elements. Sanner (Thesis, 1941) did not find any shift for the Cu $K\alpha$ doublet going from metal to oxide. Nordling, Sokolowski and Siegbahn (Ark. f. Fysik *13*, 37 (1958)) measured the absolute values of the energy levels in Cu and CuO and found shifts in the K and L levels of different magnitude. The present investigation is made on the Cu $K\alpha_{1,2}$ in metal and oxide. The spectrometer is of Johann-type utilizing a quartz crystal $1\bar{3}40$ bent to a radius of 893 mm. The detection is by means of a Geiger counter. Several runs were made, partly with a copper plate as target, partly with a silver plate on to which CuO powder was pressed. The compilation of the results gave a shift of the Cu $K\alpha_1$ line towards longer wavelength (less energy) of -0.35 ± 0.14 eV and of the Cu $K\alpha_2$ line in the same direction of -0.14 ± 0.16 eV.

Y. TORESSON, *Department of Physics, University of Lund*

Spectrum and term system of trebly ionized silicon, Si IV

The spectrum of trebly ionized silicon has been studied in the region 10 000–2000 Å by using a sliding spark in vacuum. A total of 58 spectrum lines have been measured and classified, 34 of which had not been observed before. New levels have been added to those previously known, and the whole term system has been recalculated on the basis of the new measurements, supplemented by six wavelengths in the vacuum ultraviolet measured by Professor A. G. Shenstone. The narrow splittings of the terms $3d$, $4d$, and $5d\ ^2D$ have been determined in an indirect way. The doublet $4f\ ^2F$ has been resolved directly. Some wavelengths in the ultraviolet part of spectrum have been calculated by use of the levels determined in this work.

T. VÄNNGÅRD and S. ÅKERSTRÖM, *Institutes of Physics and Organic Chemistry, University of Uppsala*

Electron spin resonance of some divalent Cu, Ag and Au sulphur compounds

Solutions of some dithiocarbamates of divalent copper, silver and gold (electron configurations $3d^9$, $4d^9$ and $5d^9$ respectively) have been studied by means of electron spin resonance. The metal ion is thought to be surrounded by four sulphur atoms arranged in a square. Our results are summarized in the following table

Isotope	g-value	Hyperfine constant
Cu^{63}	2.046	7.4×10^{-3} cm^{-1}
$Ag^{107,109}$	2.019	2.7×10^{-3} cm^{-1}
Au^{197}	2.040	2.8×10^{-3} cm^{-1}

This as far as we know for the first time demonstrates the existence of divalent gold.

I. WAHLSTRÖM and B. FORKMAN, *Department of Physics, University of Lund*

Photoprotons from nitrogen

Nitrogen has been bombarded with bremsstrahlung of 12 and 15 MeV maximum energy. The emitted photoprotons were recorded by nuclear emulsions. Both irradiations give proton spectra containing well resolved peaks. Angular distribution of the strongest peak has been recorded. Comparing with known levels in N^{14} and C^{13} gives information about the photodisintegration process. The results are compared with the inverse process $C^{13}(p,\gamma)N^{14}$.

O. WERNHOLM, *Department of Electronics, Royal Institute of Technology, Stockholm*

Microtron injector for a synchrotron

A 5.8 MeV microtron will be used as an injector for a 1200 MeV synchrotron. Operation principle and characteristics of the injector will be briefly described. A magnetic channel is used for the extraction of the electron beam from the microtron magnetic field. This channel, together with the apparatus necessary for the transfer of the beam into the synchrotron, will also be described.

T. WESTERMARK, *Division of Physical Chemistry, Royal Institute of Technology, Stockholm*

Experimental studies on the electron energy distribution and energy stability of a 5 MeV betatron

The 5 MeV betatron of the Royal Institute of Technology (Wernholm-Smårs) has been adopted to a project on electron energy losses in matter. (Ark. f. Fysik *13*, 294

(1958), short note). The energy spread of the beam has been studied in some detail with a double-focusing magnetic spectrometer in order to find the narrowest energy distribution. There seems to be a limit corresponding to about 0.15 % (2.8 MeV). The limitation may be inherent in the beam itself (perhaps due to the oscillations) or due to collisions in the deflector construction.—The energy stability is better than 0.01 %.—Preliminary results on energy loss studies in LiH and other substances are given in the lecture.

E. WITALIS, *Department of Electronics, Royal Institute of Technology, Stockholm*

Measurements on a magnetized plasma from a coaxial plasma gun

The magnetic field inside and outside the plasma ring described by Lindberg is meeasured with loops outside the discharge tube. In some cases the magnetic field is much larger than expected. The influence of pre-ionization, pressure and other parameters on the plasma ring has been investigated. Photographic, spectroscopic and calorimetric measuring methods give information about the plasma, and a piezoelectric probe is used for pressure measurements. Attempts to retard the plasma ring by external magnetic fields turn out less successful.

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